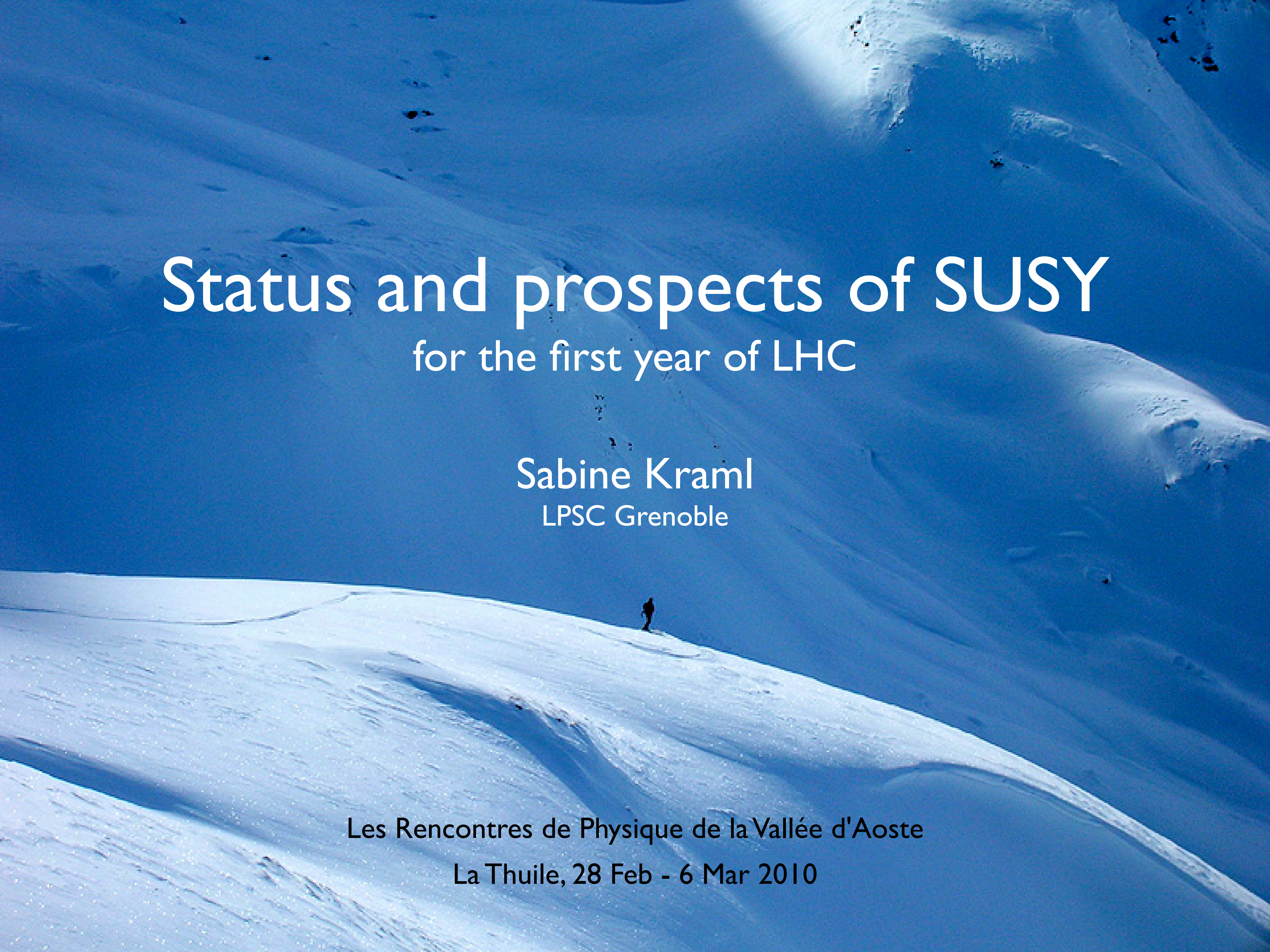


Status and prospects of SUSY

for the first year of LHC

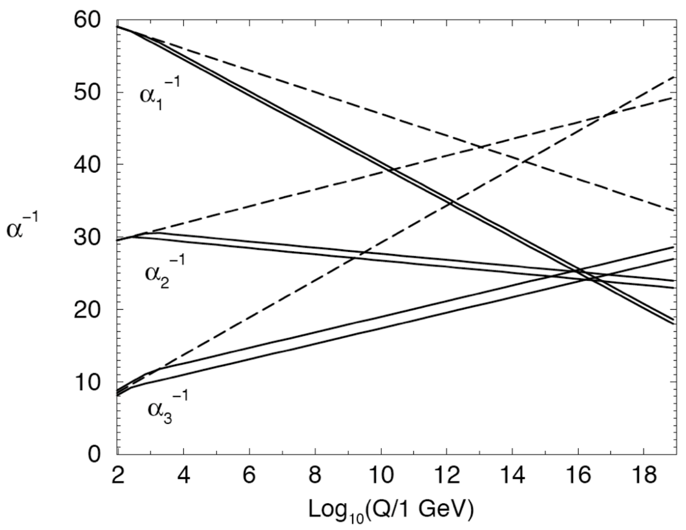
Sabine Kraml
LPSC Grenoble

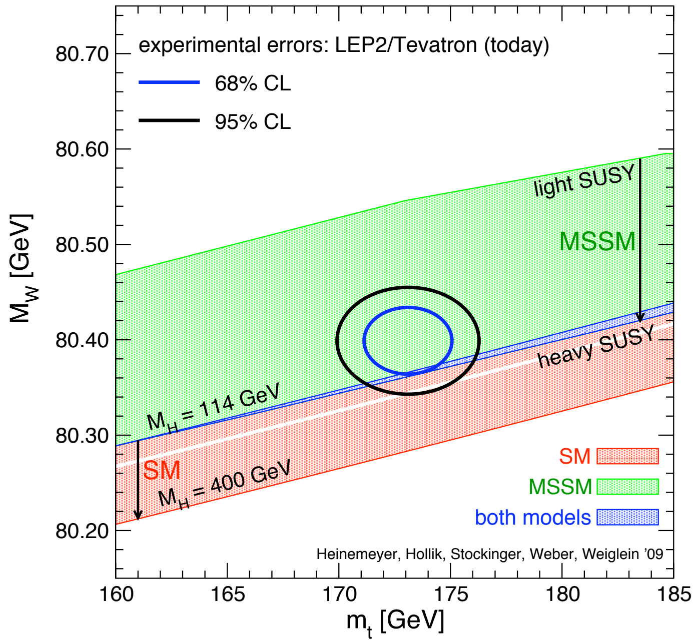
Les Rencontres de Physique de la Vallée d'Aoste

La Thuile, 28 Feb - 6 Mar 2010

Why SUSY?

- Symmetry between fermions and bosons, providing a unified description of matter, gauge and Higgs fields.
- Unique extension of relativistic space-time symmetries.
- Solves the gauge hierarchy problem.
- Predicts a light Higgs.
- Allows for gauge coupling unification → GUT?
- Excellent fit to precision electroweak data.
- Provides cold dark matter candidate
- Arguably the best motivated extension of the SM





MSSM

Minimal supersymmetric standard model

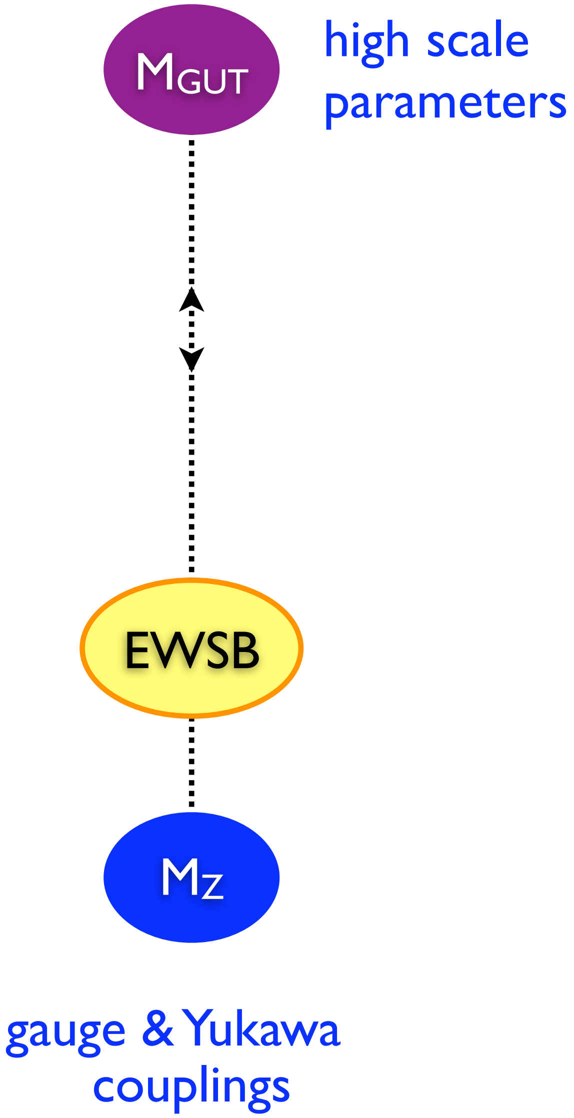
particle	spin	superpartner	spin
quarks	$1/2$	squarks	0
leptons	$1/2$	sleptons	0
gauge bosons	1	gauginos	$1/2$
Higgs bosons	0	higgsinos	$1/2$
graviton	2	gravitino	$3/2$

full MSSM: ~100 free parameters (soft breaking terms)

CMSSM (mSUGRA): $m_{1/2}$, m_0, A_0, $\tan\beta$, sign μ.

NUHM: $m_{1/2}$, m_0, $m_{H_{1,2}}$, A_0, $\tan\beta$, sign μ.

NUHM-1: $m_{H_1} = m_{H_2}$, NUHM-2: $m_{H_1} \neq m_{H_2}$



M_{GUT}

high scale parameters

EWSB

M_Z

gauge & Yukawa couplings

MSSM

Minimal supersymmetric standard model

particle	spin	superpartner	spin
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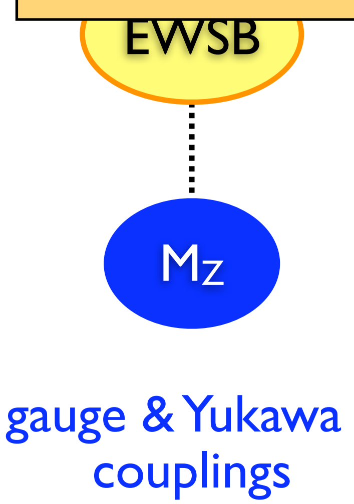
Disclaimer:
There's been a lot of work recently regarding low-scale SSB*, SSB from extra dimensions, string-inspired models, non-universal / non-minimal models, higgsless SUSY, etc, etc. These will not be discussed here.

* SSB=soft SUSY breaking



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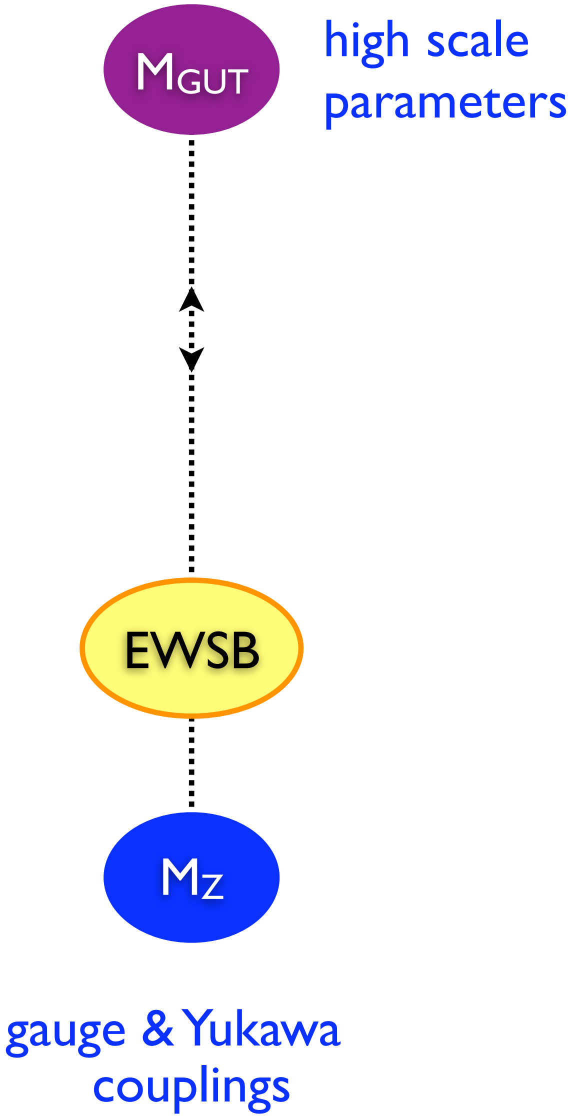

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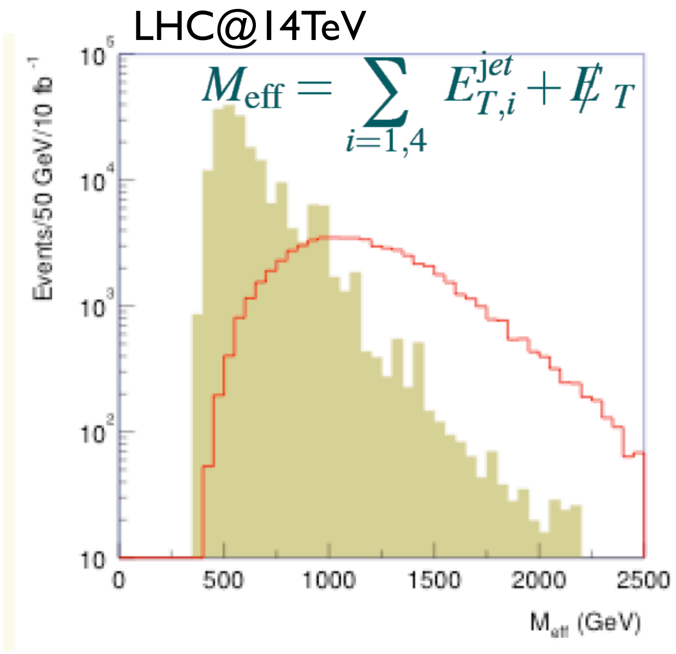
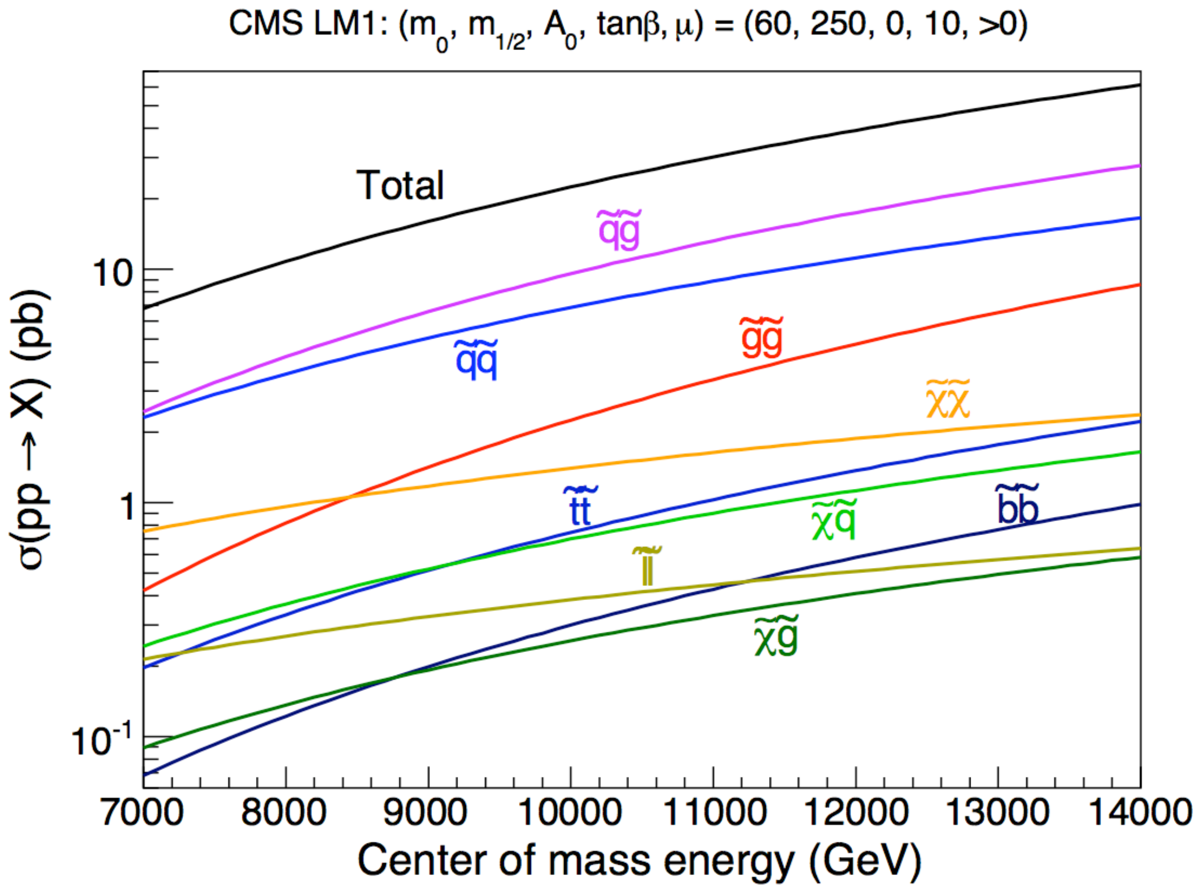
Cross sections at LHC

- Large Xsections for squarks and/or gluinos (strong interaction)
- Once produced, they will decay into lighter sparticles until the LSP* is reached
  - ➡ cascade decays
  - ➡ high-p_T jets
  - ➡ large missing E_T





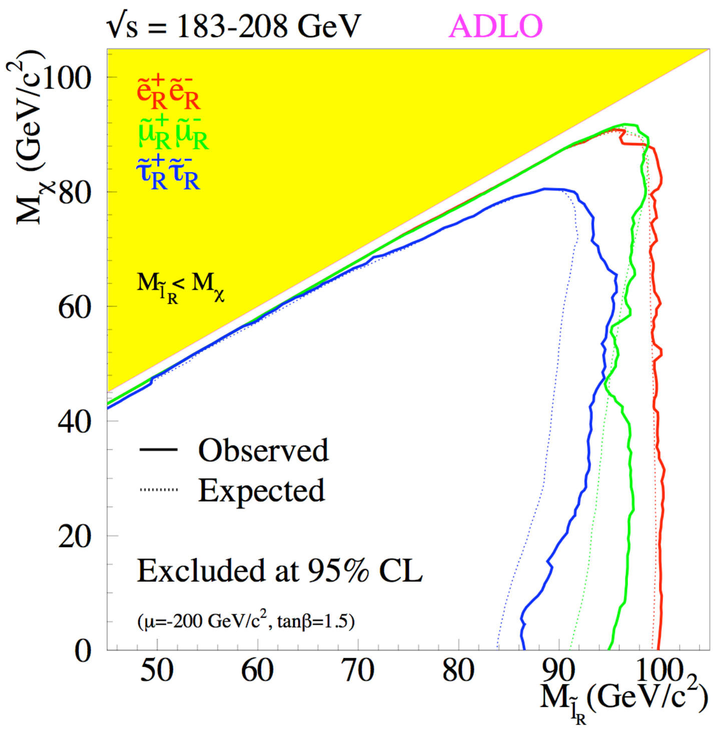
courtesy S. Sekmen

*) LSP = lightest SUSY particle, stable if R-parity is conserved

Limits and constraints

So far only lower mass limits and indirect constraints, e.g.,

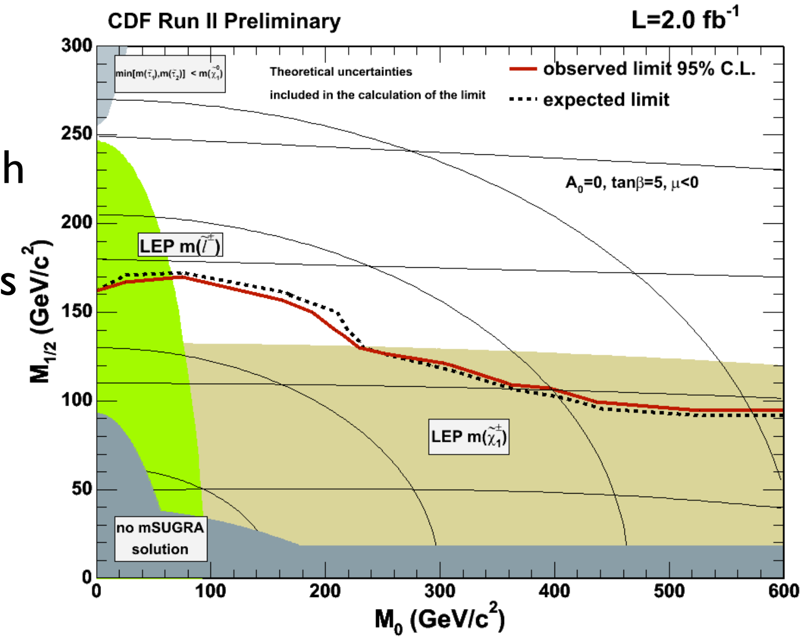
LEP: charged sparticle $M \gtrsim 100$ GeV

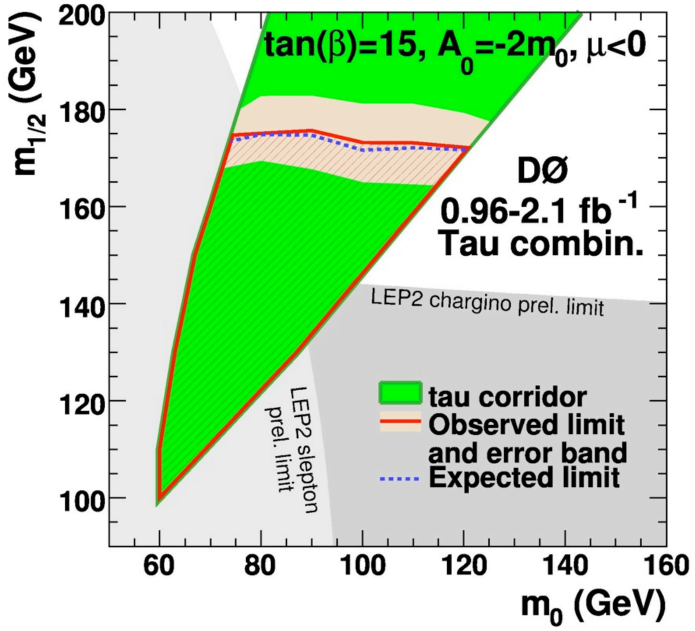


$\mathrm{BR}^{\mathrm{exp}}_{b\to s\gamma}/\mathrm{BR}^{\mathrm{SM}}_{b\to s\gamma}$	$1.117 \pm 0.076_{\mathrm{exp}} \pm 0.082_{\mathrm{th(SM)}}$
$\mathrm{BR}(B_s \to \mu^+\mu^-)$	$< 4.7 \times 10^{-8}$
$\mathrm{BR}^{\mathrm{exp}}_{B\to\tau\nu}/\mathrm{BR}^{\mathrm{SM}}_{B\to\tau\nu}$	$1.25 \pm 0.40_{[\mathrm{exp+th}]}$
$\mathrm{BR}(B_d \to \mu^+\mu^-)$	$< 2.3 \times 10^{-8}$
$\mathrm{BR}^{\mathrm{exp}}_{B\to X_s\ell\ell}/\mathrm{BR}^{\mathrm{SM}}_{B\to X_s\ell\ell}$	0.99 ± 0.32
$\mathrm{BR}^{\mathrm{exp}}_{K\to\mu\nu}/\mathrm{BR}^{\mathrm{SM}}_{K\to\mu\nu}$	$1.008 \pm 0.014_{[\mathrm{exp+th}]}$
$\mathrm{BR}^{\mathrm{exp}}_{K\to\pi\nu\bar{\nu}}/\mathrm{BR}^{\mathrm{SM}}_{K\to\pi\nu\bar{\nu}}$	< 4.5
$\Delta M^{\mathrm{exp}}_{B_s}/\Delta M^{\mathrm{SM}}_{B_s}$	$0.97 \pm 0.01_{\mathrm{exp}} \pm 0.27_{\mathrm{th(SM)}}$
$\frac{(\Delta M^{\mathrm{exp}}_{B_s}/\Delta M^{\mathrm{SM}}_{B_s})}{(\Delta M^{\mathrm{exp}}_{B_d}/\Delta M^{\mathrm{SM}}_{B_d})}$	$1.00 \pm 0.01_{\mathrm{exp}} \pm 0.13_{\mathrm{th(SM)}}$
$\Delta\epsilon^{\mathrm{exp}}_K/\Delta\epsilon^{\mathrm{SM}}_K$	$1.08 \pm 0.14_{[\mathrm{exp+th}]}$
$a^{\mathrm{exp}}_\mu - a^{\mathrm{SM}}_\mu$	$(30.2 \pm 8.8) \times 10^{-10}$
M_h [GeV]	> 114.4 (see text)
$\Omega_{\mathrm{CDM}}h^2$	0.1099 ± 0.0062

B-physics!

Tevatron: begins to reach beyond LEP but mass limits quite model dependent





→ severe constraints on parameter space

S. Kraml

Fits: Bayesian

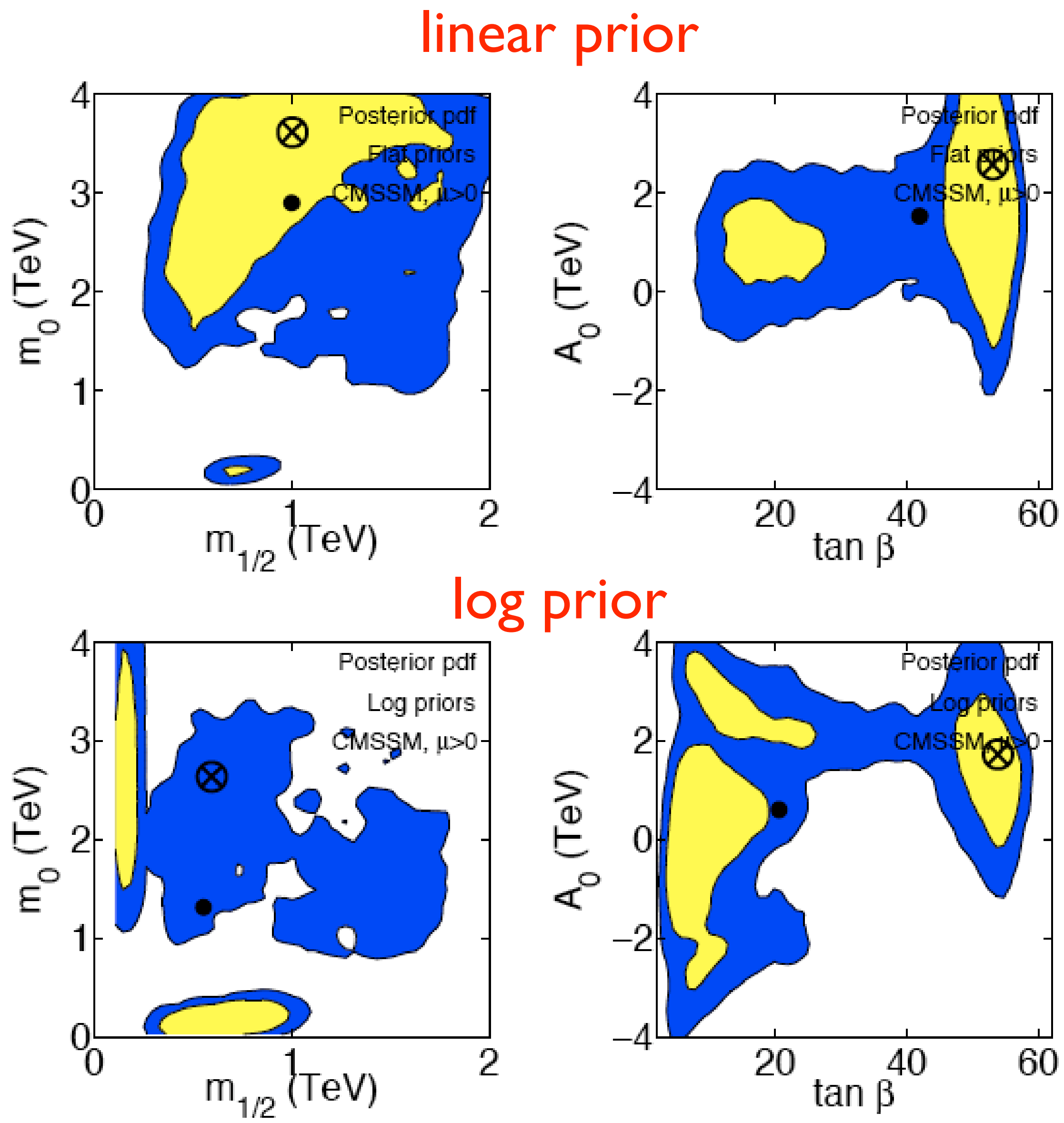
Allanach, Lester,
AbdusSalam et al,
Baltz, Gondolo,
Belanger et al,
Roszkowski et al,

- Markov Chain Monte Carlo (MCMC) or MultiNest sampling.
- Marginalized posterior PDFs (probability density functions) for parameter inference.

$$\overset{\text{posterior}}{p(m|d)} = \frac{\overset{\text{likelihood}}{p(d|\xi)}\,\overset{\text{prior}}{\pi(m)}}{\underset{\text{evidence}}{p(d)}}$$

- Alternative: profile likelihoods, but more difficult to evaluate.
- Prior dependence!!

PHYS+NUIS+COLL
+CDM+BSG



Trotta et al, arXiv:0809.3792

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likelihood prior

posterior

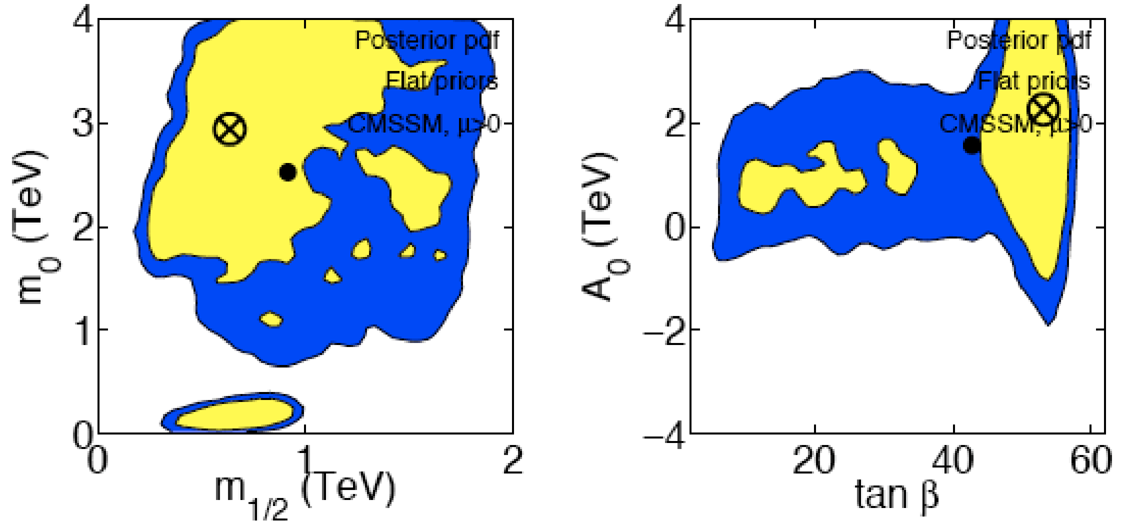
$$p(m|d) = \frac{p(d|\xi)\pi(m)}{p(d)}$$

evidence

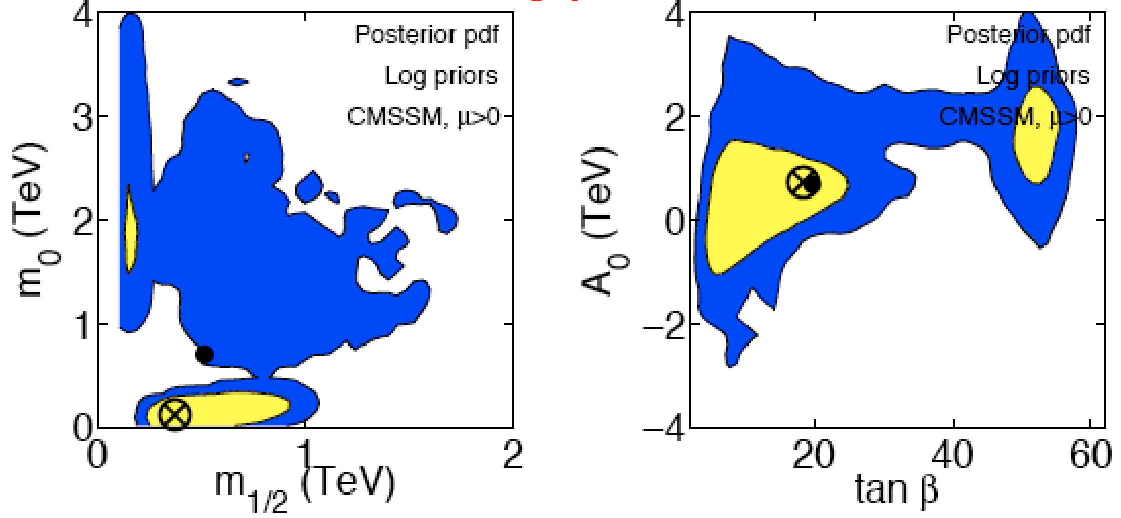
- Alternative: profile likelihoods, but more difficult to evaluate.
- Prior dependence!!

PHYS+NUIS+COLL
+CDM+BSG+(G-2)

linear prior



log prior

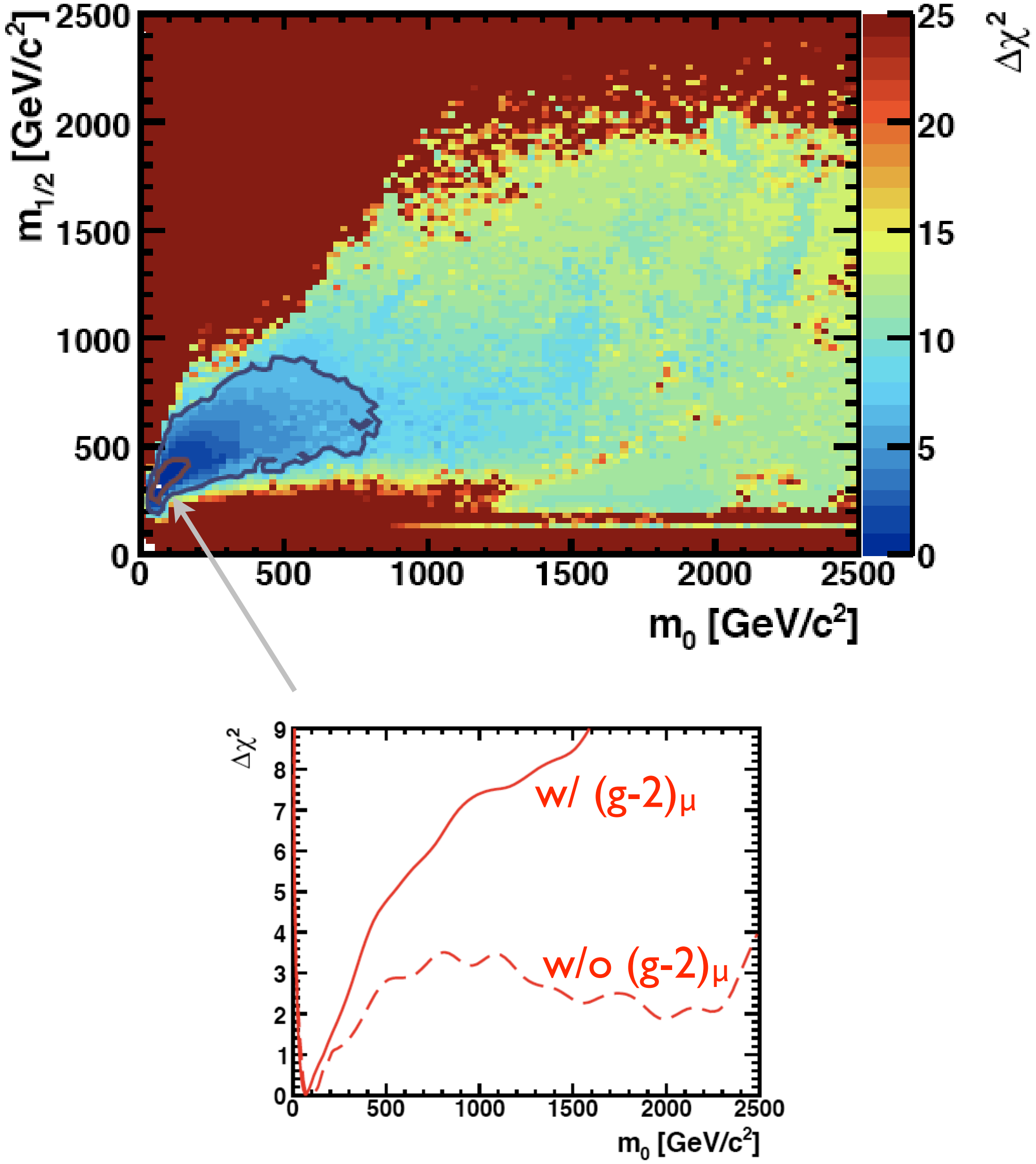


Trotta et al, arXiv:0809.3792

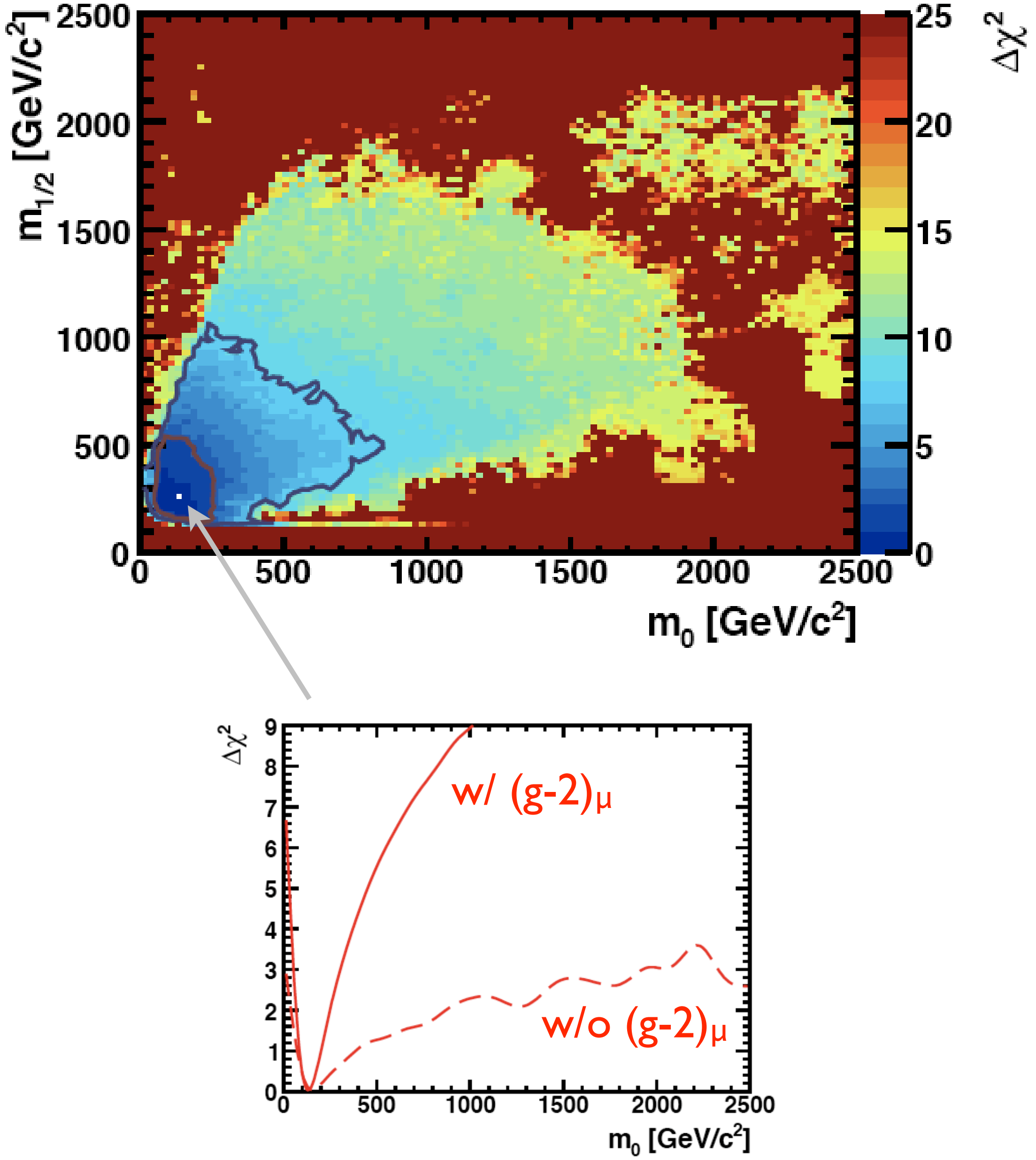
O. Buchmüller et al, arXiv:0907.5568
("Mastercode")

Fits: Frequentist

CMSSM



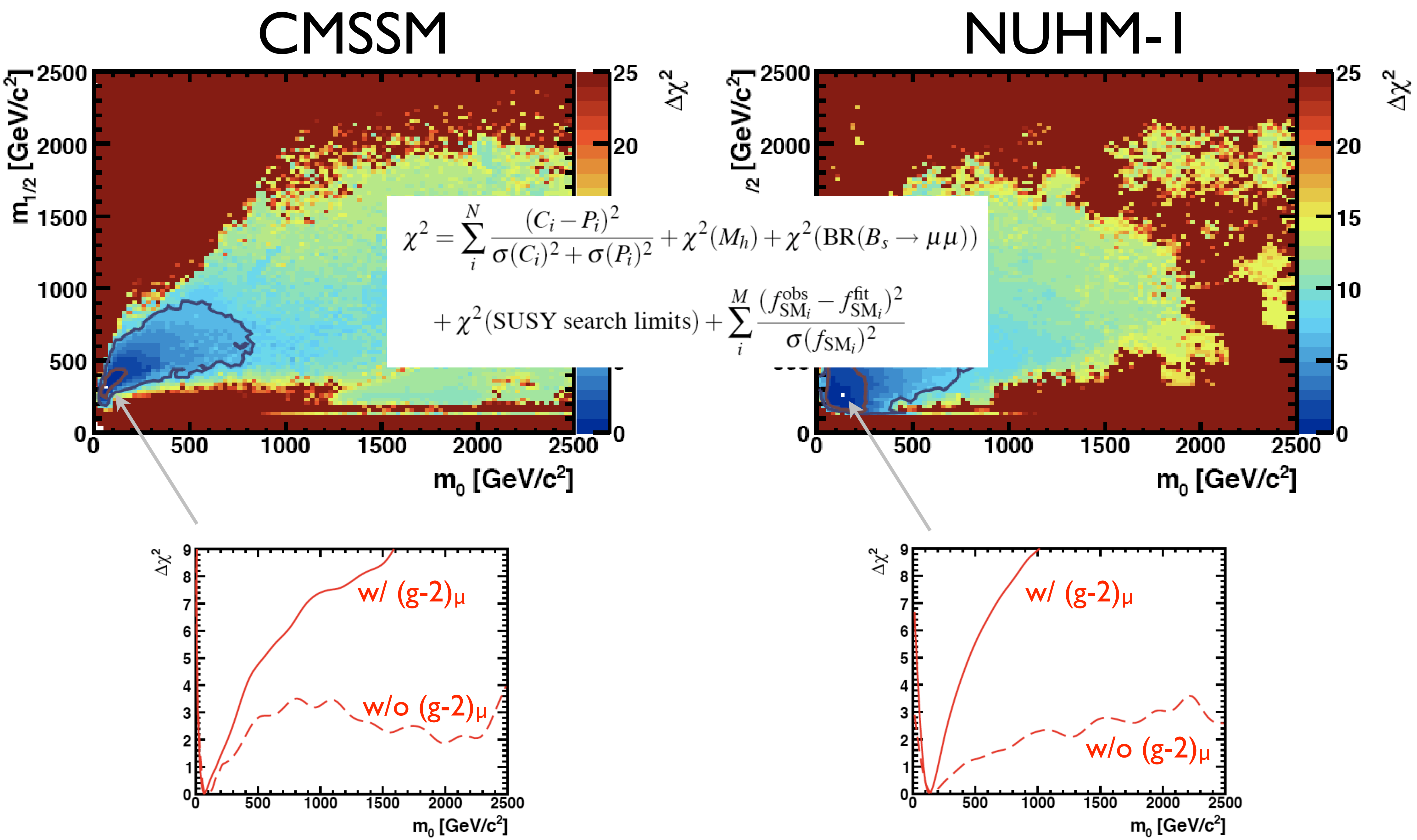
NUHM-1



Best fit at $m_{\tilde{g}} \approx \mathbf{750/600}$ GeV, $\tan\beta \approx 11\,.$

O. Buchmüller et al, arXiv:0907.5568
("Mastercode")

Fits: Frequentist



CMSSM

NUHM-1

$$\chi^2 = \sum_i^N \frac{(C_i-P_i)^2}{\sigma(C_i)^2+\sigma(P_i)^2} + \chi^2(M_h) + \chi^2(\mathrm{BR}(B_s \to \mu\mu))$$

$$+ \chi^2(\text{SUSY search limits}) + \sum_i^M \frac{(f^{\rm obs}_{\mathrm{SM}_i} - f^{\rm fit}_{\mathrm{SM}_i})^2}{\sigma(f_{\mathrm{SM}_i})^2}$$

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O. Buchmüller et al, arXiv:0907.5568
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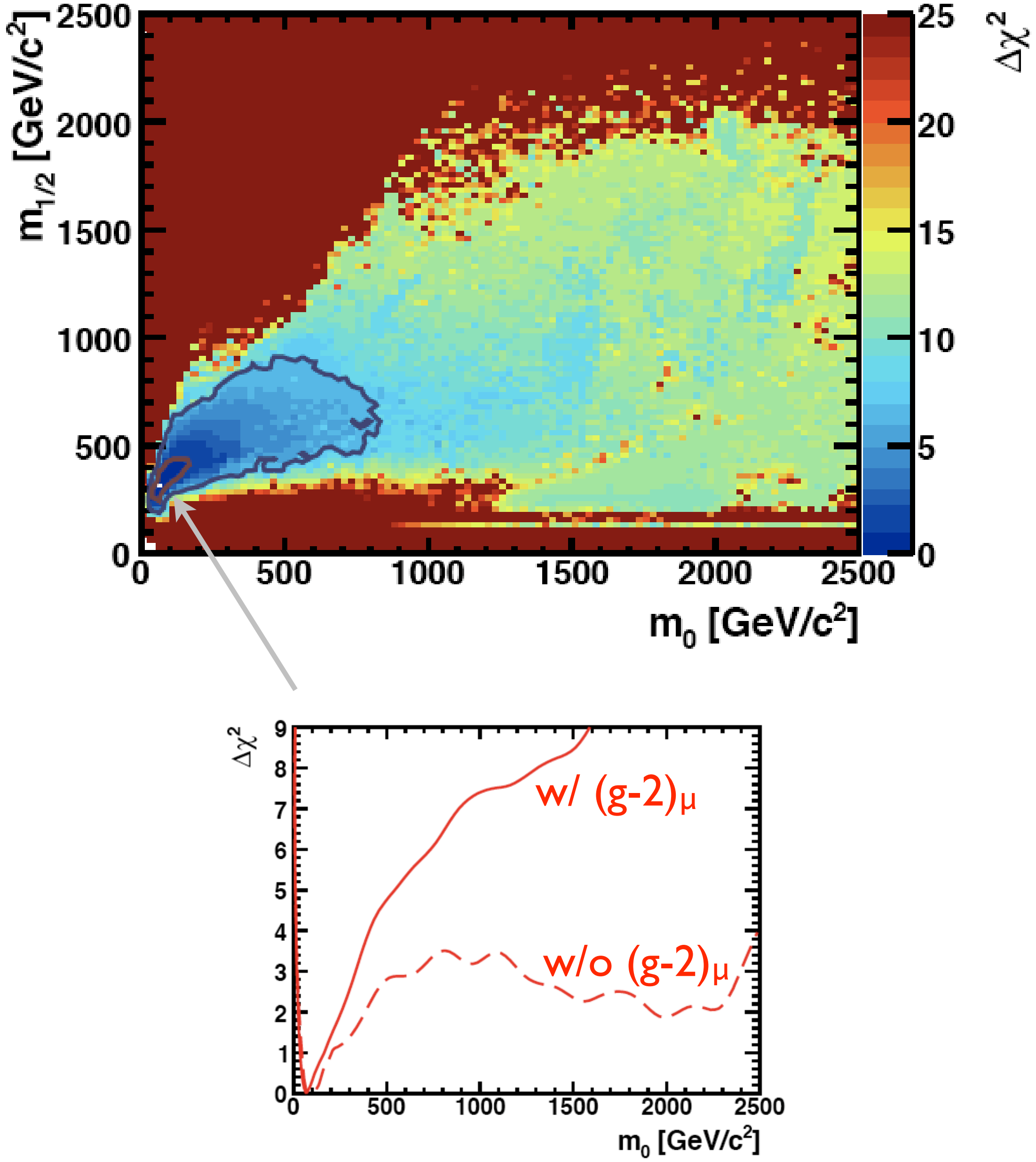
Fits: Frequentist

CMSSM



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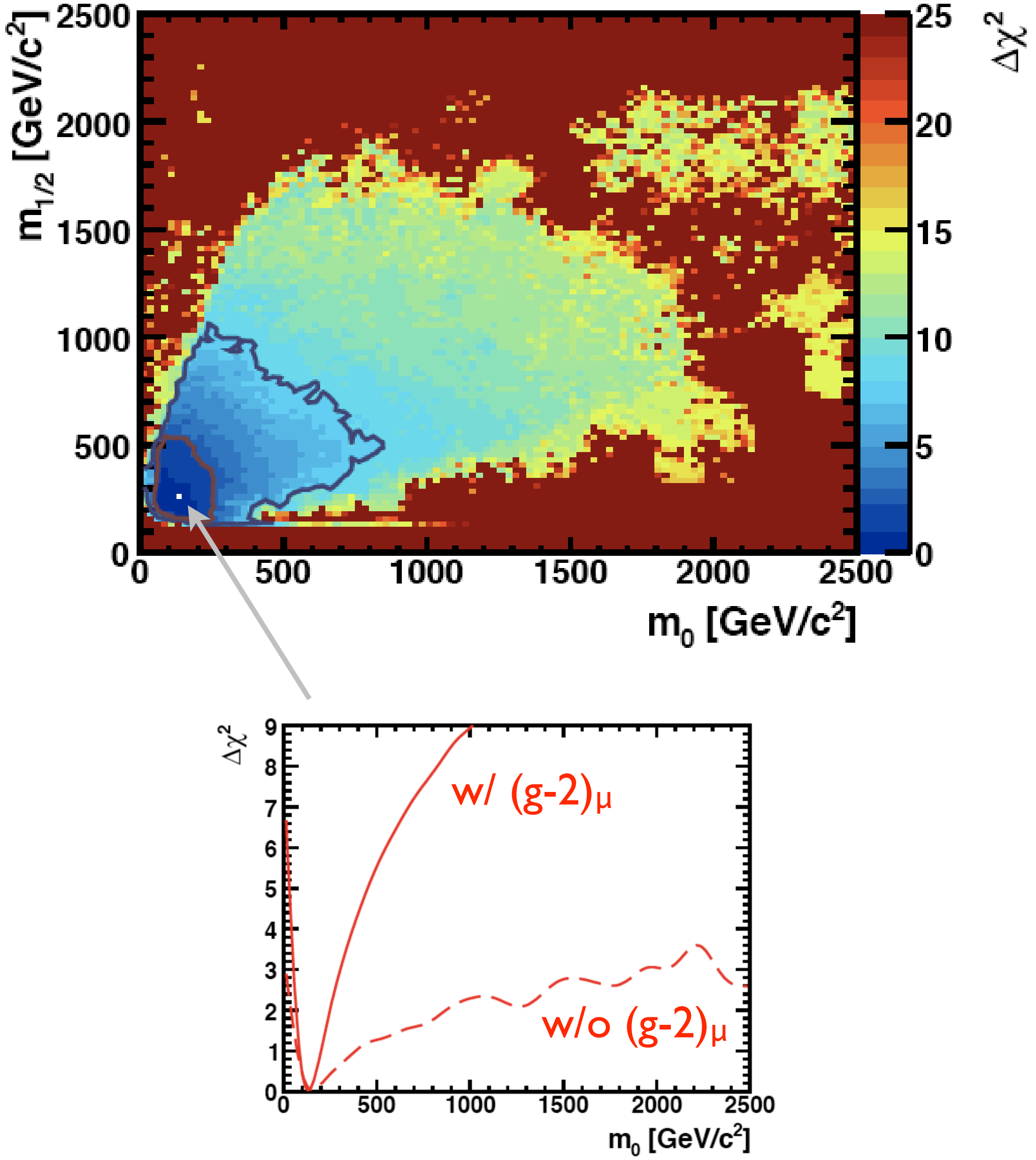

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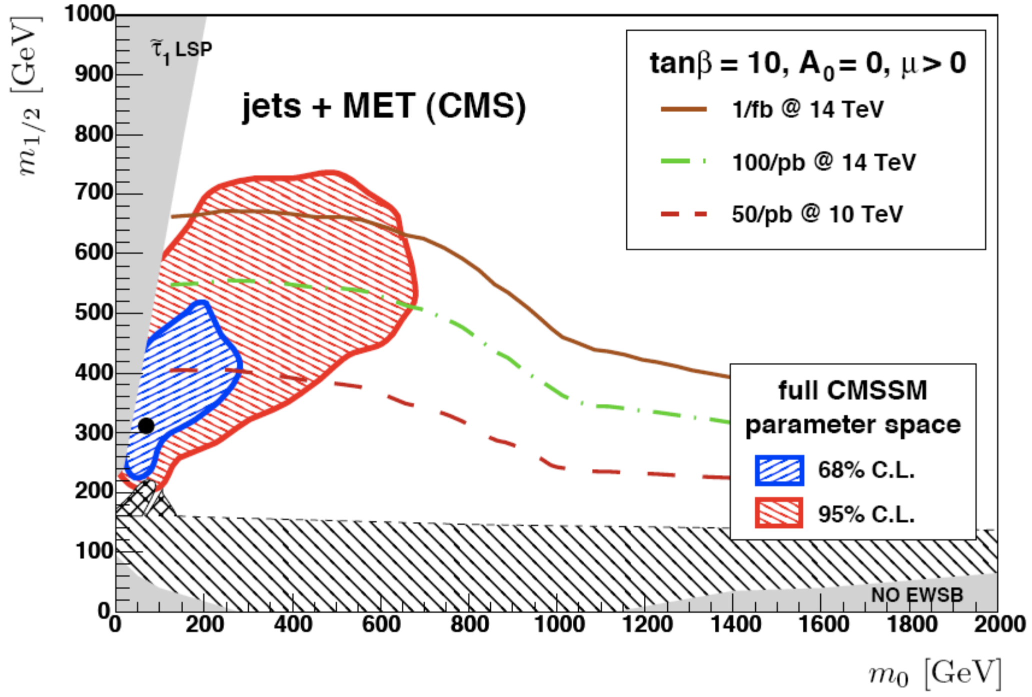
O. Buchmüller et al,
0808.4128, 0907.5568
("Mastercode")

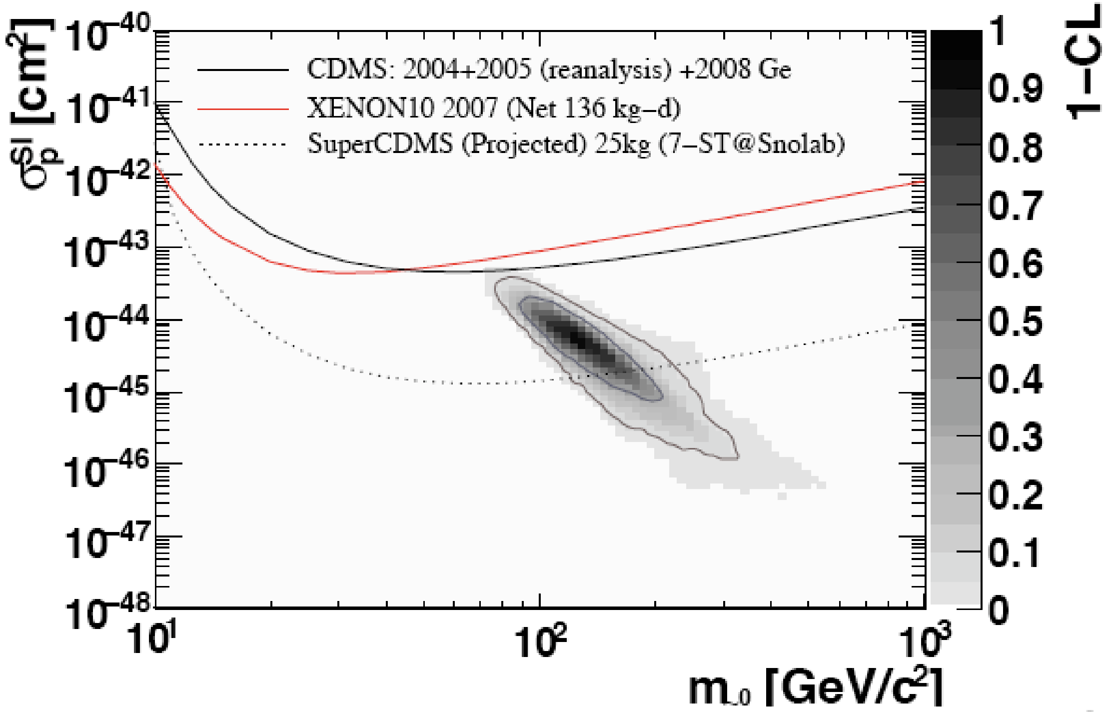
Fits: Frequentist

LHC potential

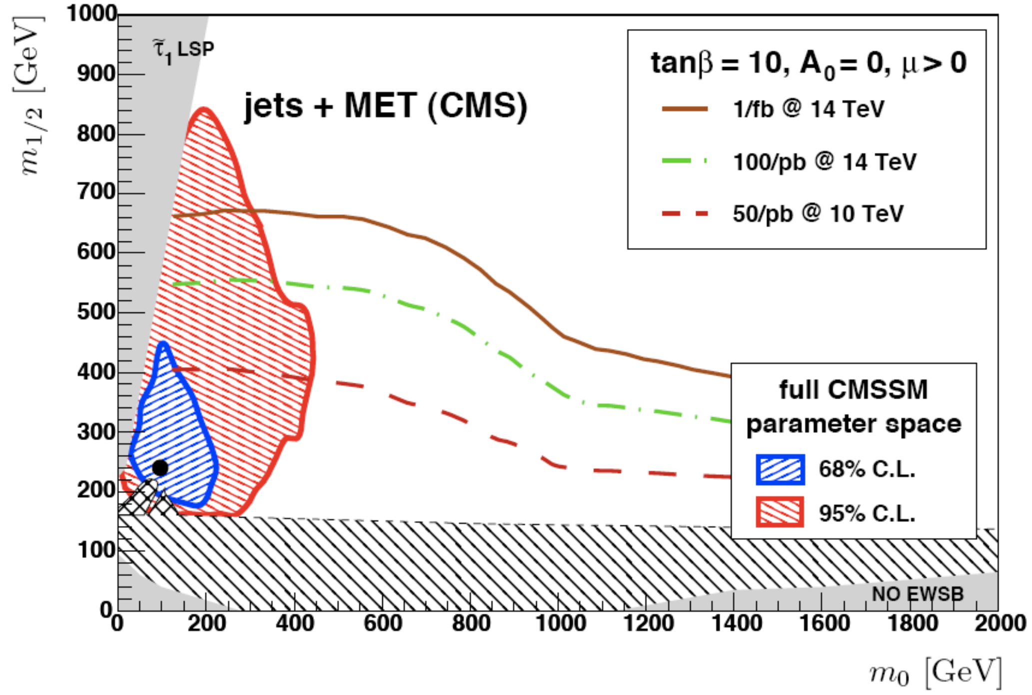
Direct DM search

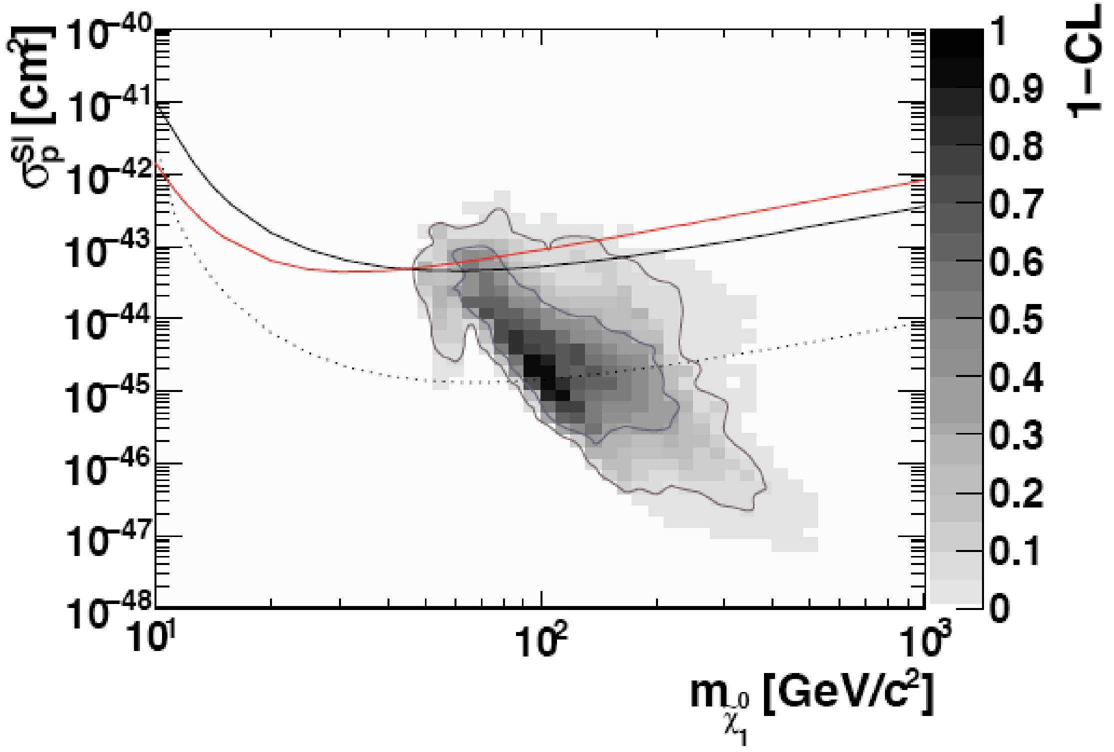
CMSSM





NUHM-1





O. Buchmüller et al, arXiv:0907.5568
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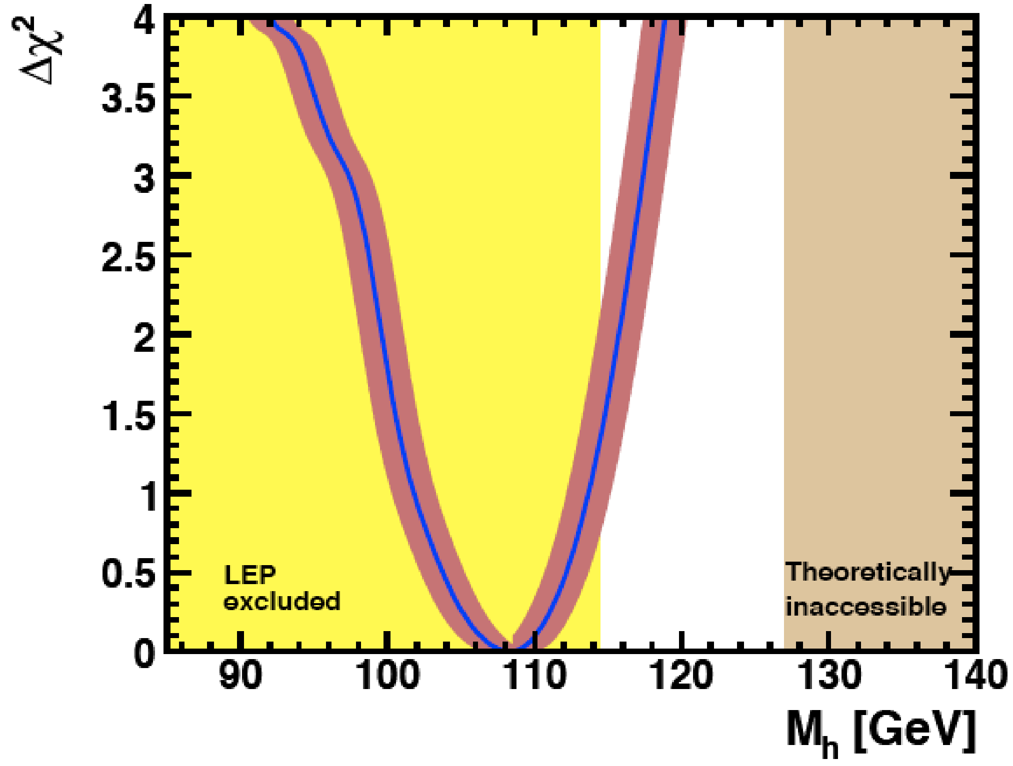
Fit of Higgs mass

CMSSM



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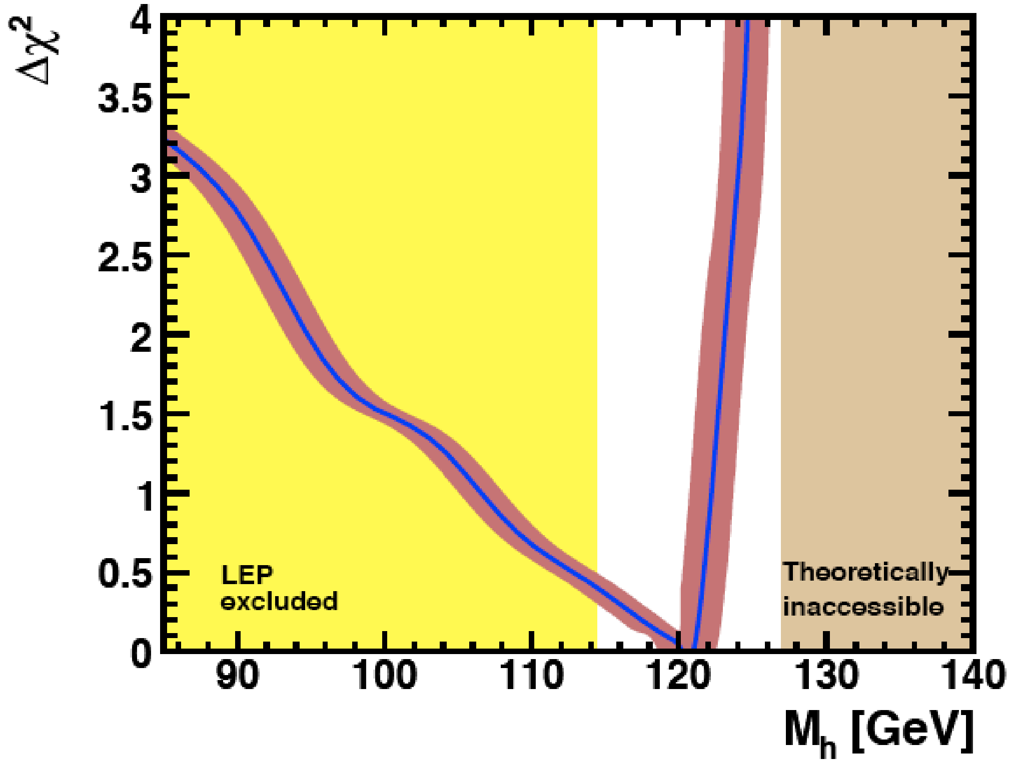

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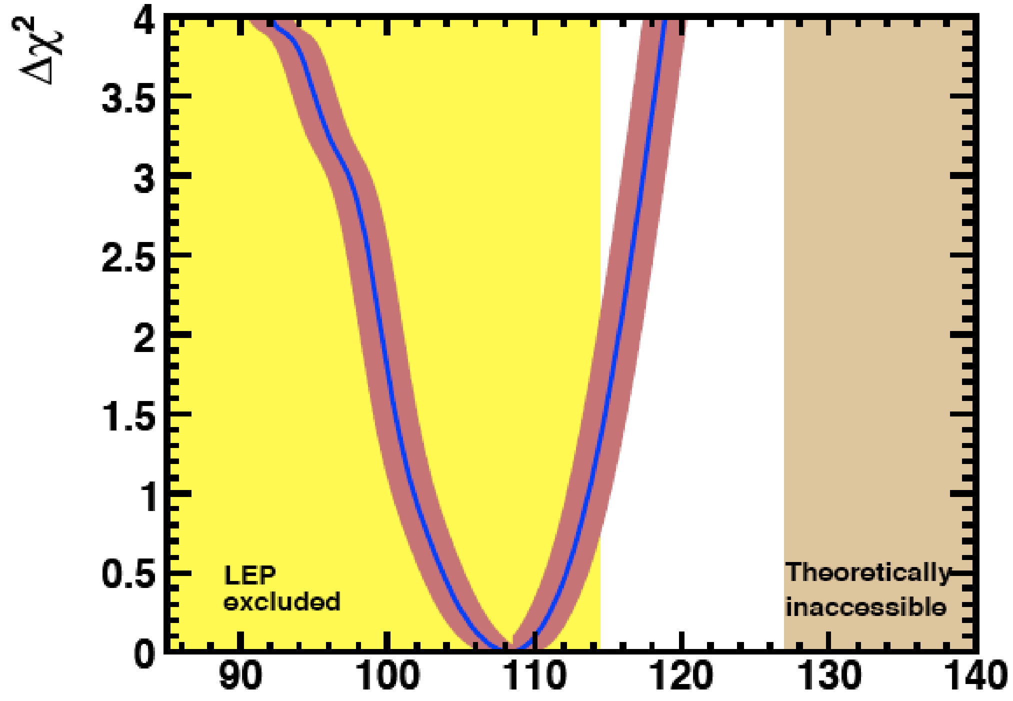
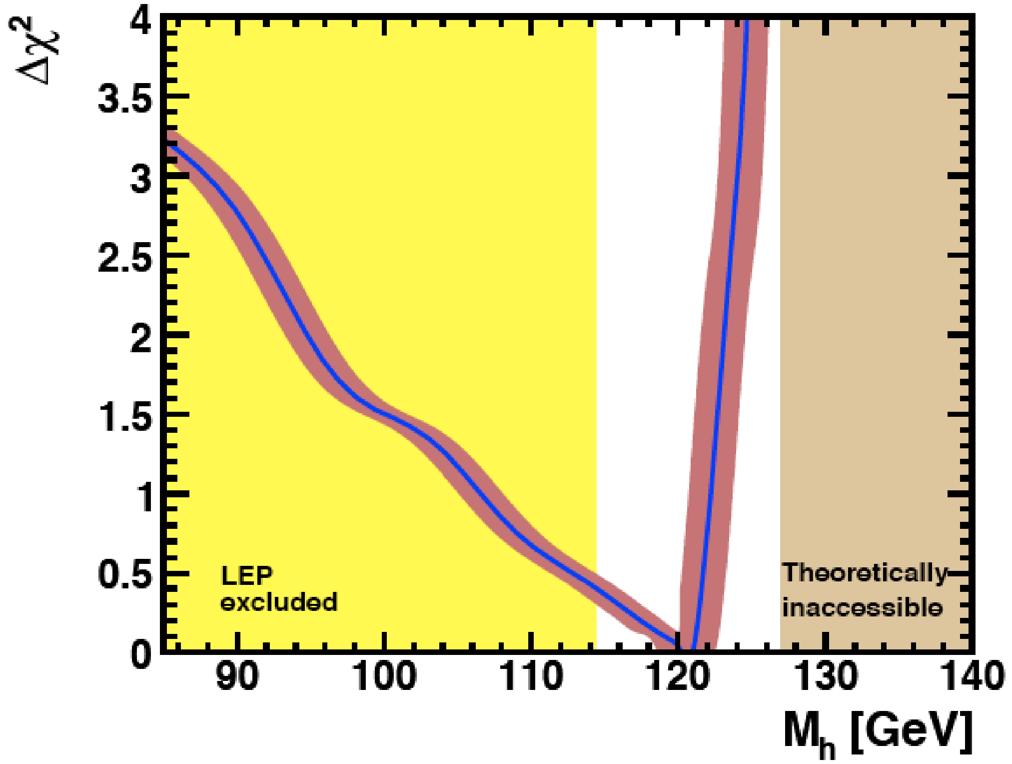
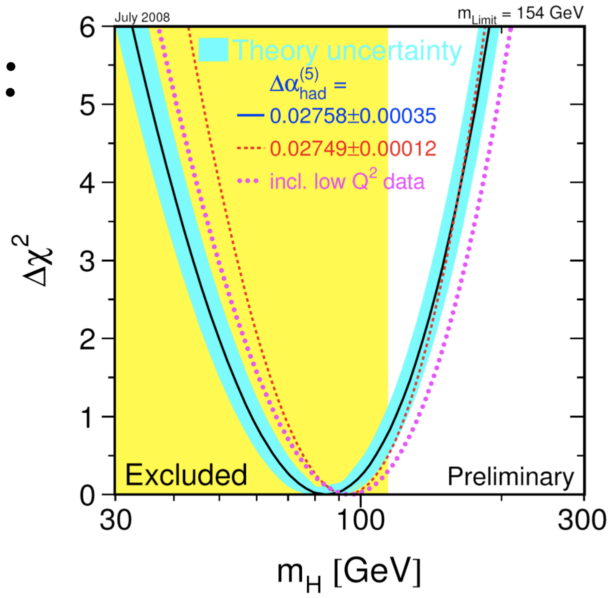
CMSSM



NUHM-1



SM:



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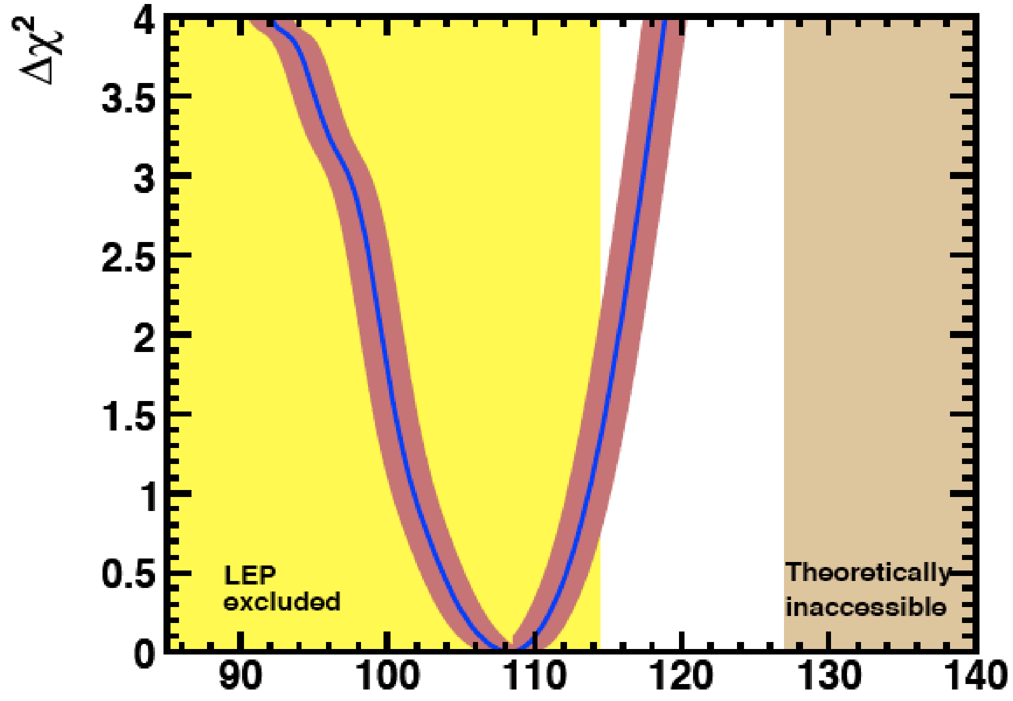

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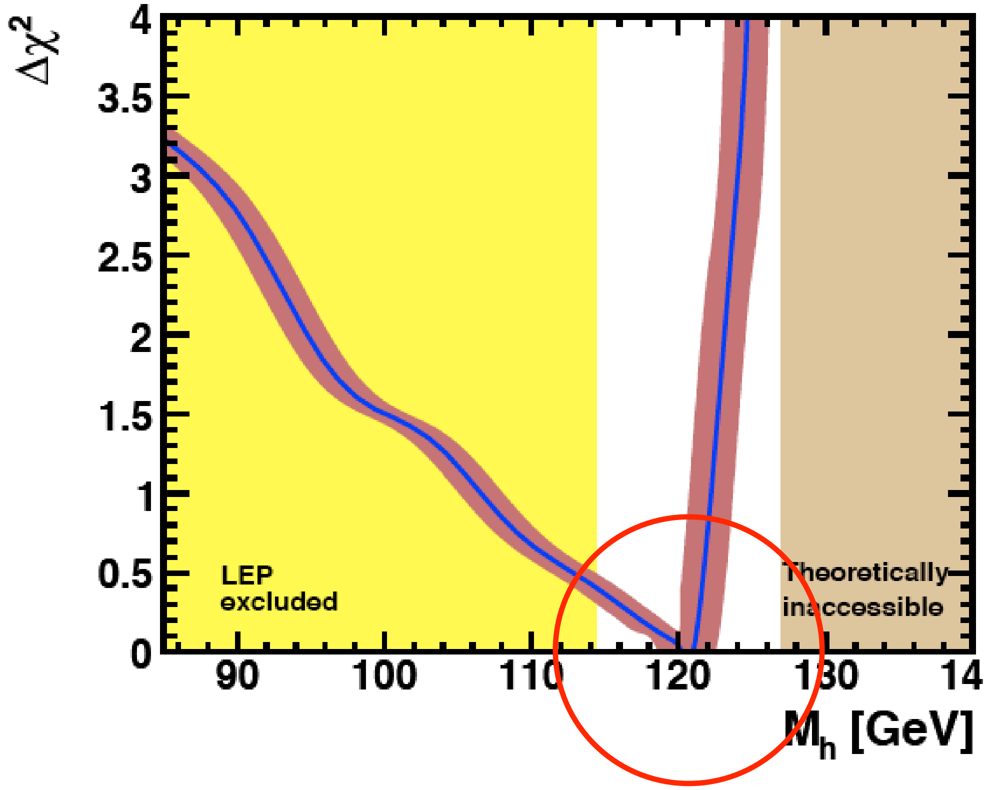
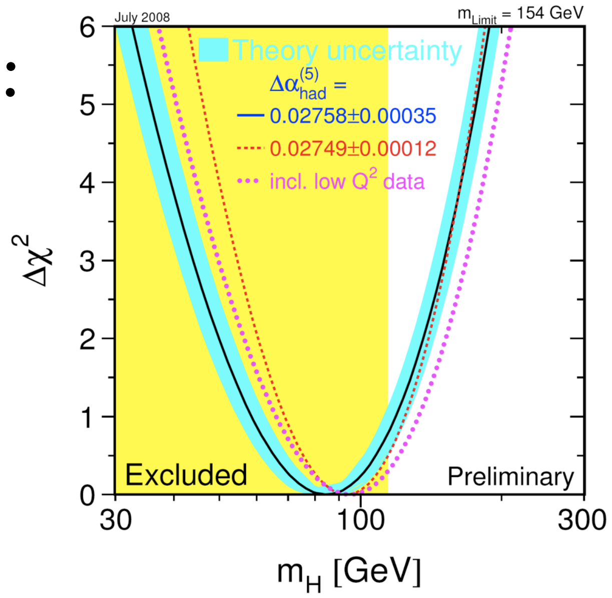


above the LEP bound!

SM:

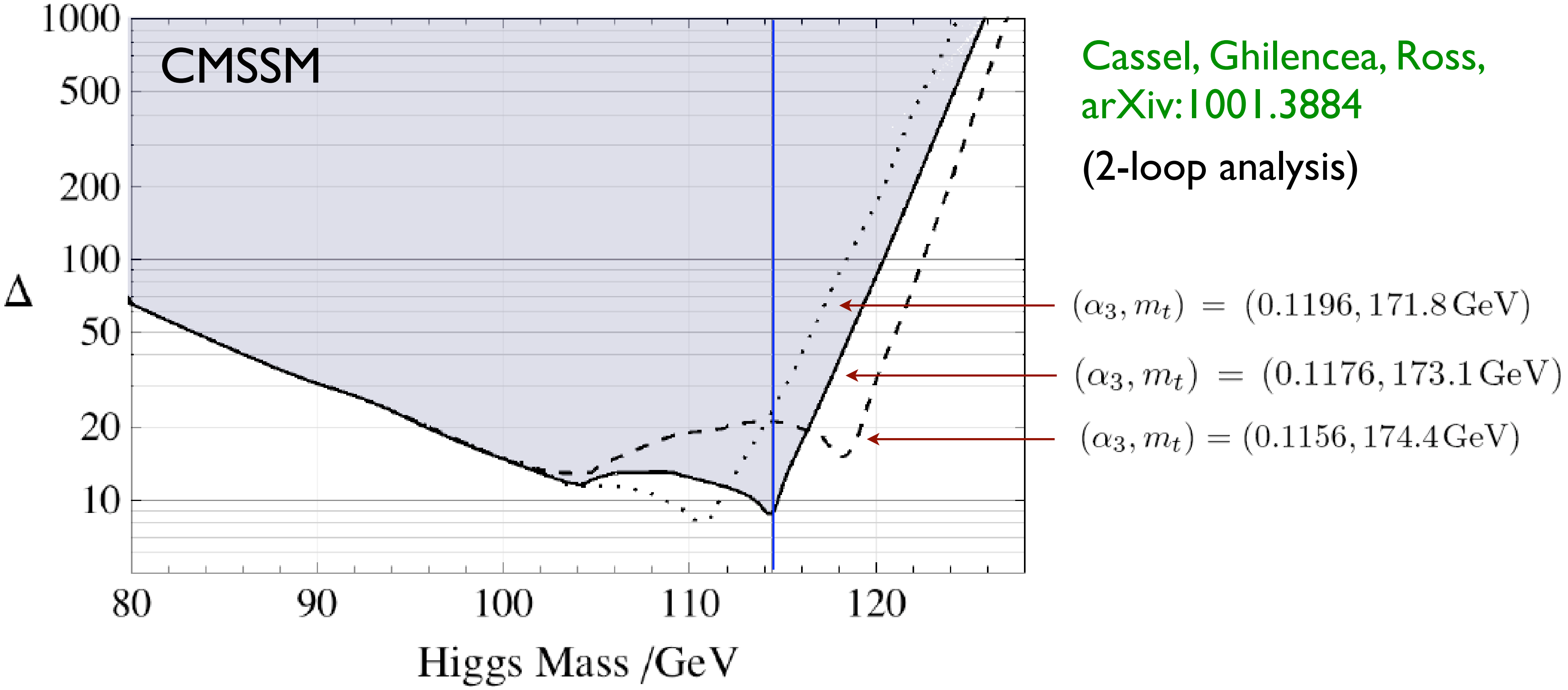


see also
Barbieri et al.,
Chankowski et al.,
....

The finetuning price

- Finetuning = sensitivity of EW scale to input parameters

$$\frac{M_Z^2}{2} \approx -m_{H_2}^2 - |\mu|^2$$



Cassel, Ghilencea, Ross,
arXiv:1001.3884

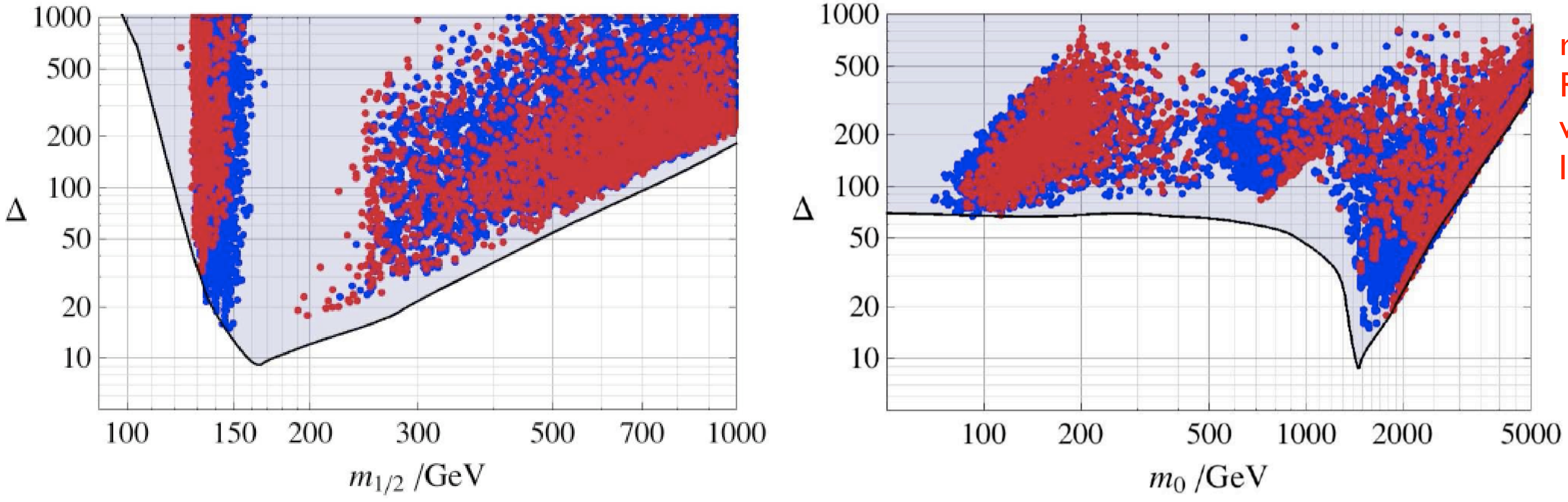
(2-loop analysis)

$$\Delta \equiv \max \left|\Delta_p\right|_{p=\{\mu_0^2, m_0^2, m_{1/2}^2, A_0^2, B_0^2\}}, \qquad \Delta_p \equiv \frac{\partial \ln v^2}{\partial \ln p}$$

S. Kraml

Cassel, Ghilencea, Ross,
arXiv:1001.3884

CMSSM low finetuning



red points:
Relic density
within WMAP
limit (at 3σ)

NB: points with lowest finetuning lie in the focus point region

- gaugino-higgsino mixing
- light gluino
- Xsections a few pb at 7TeV LHC

$BR(\tilde{g} \to \tilde{\chi}_i^0 g) \sim 10-20\%$

$BR(\tilde{g} \to \tilde{\chi}_i^0 b\bar{b}, \tilde{\chi}_i^{\pm} tb) \sim 20\%$

h^0	114.5	$\tilde{\chi}_1^0$	79	$\tilde{b}_1$	1147	$\tilde{u}_L$	1444
H^0	1264	$\tilde{\chi}_2^0$	142	$\tilde{b}_2$	1369	$\tilde{u}_R$	1446
$H^{\pm}$	1267	$\tilde{\chi}_3^0$	255	$\tilde{\tau}_1$	1328	$\tilde{d}_L$	1448
A^0	1264	$\tilde{\chi}_4^0$	280	$\tilde{\tau}_2$	1368	$\tilde{d}_R$	1446
$\tilde{g}$	549	$\tilde{\chi}_1^{\pm}$	142	$\tilde{\mu}_L$	1406	$\tilde{s}_L$	1448
$\tilde{\nu}_{\tau}$	1366	$\tilde{\chi}_2^{\pm}$	280	$\tilde{\mu}_R$	1406	$\tilde{s}_R$	1446
$\tilde{\nu}_{\mu}$	1404	$\tilde{t}_1$	873	$\tilde{e}_L$	1406	$\tilde{c}_L$	1444
$\tilde{\nu}_e$	1404	$\tilde{t}_2$	1158	$\tilde{e}_R$	1406	$\tilde{c}_R$	1446

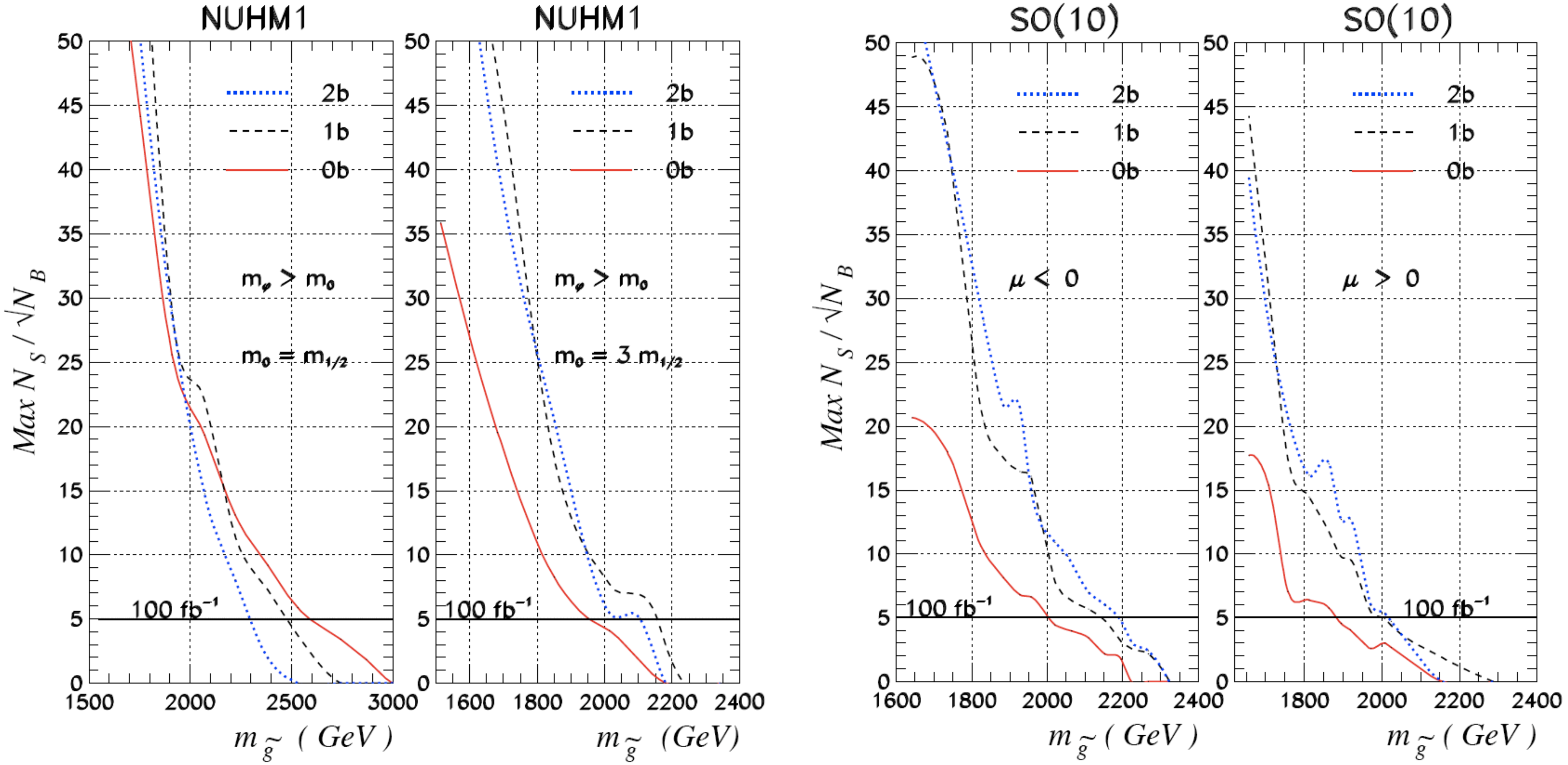
upper limits for Δ<100

$\tilde{g}$	χ_1^0	χ_2^0	χ_3^0	χ_4^0	$\chi_1^{\pm}$	$\chi_2^{\pm}$	$\tilde{t}_1$	$\tilde{t}_2$	$\tilde{b}_1$	$\tilde{b}_2$
1720	305	550	660	665	550	670	2080	2660	2660	3140

Kadala, Mercadante, Mizukoshi, Tata, arXiv:0803.0001

Importance of b-tagging

- Requiring 1, 2, or more b-jets can significantly enhance the signal/bg in certain scenarios, e.g., 15-20% in the CMSSM focus point region.



14 TeV

- Typical if 3rd generation is lighter then 1st/2nd gen. and $m_{\tilde{g}} \ll m_{\tilde{q}}$; enhances gluino decays into t or b via on- or off-shell stop/sbottom

Yukawa-unified SUSY

- SUSY GUTs based on SO(10) are particularly compelling
  - unify all matter of one generation in a 16-plet (incl. r.h. neutrino!)
  - automatic anomaly cancellation
- In the simplest realization the Higgs doublets reside in a10-plet. This then requires t-b-tau Yukawa coupling unification in addition to gauge coupling unification at M_{GUT}.
- Parameter space:
  - common gaugino mass $m_{1/2}$
  - common sfermion mass parameter m_{16}
  - common Higgs mass parameter m_{10}
  - common trilinear coupling A_0
  - $\tan\beta$ and sign(μ)
  - D-term contribution M_D^2 from SO(10) breaking

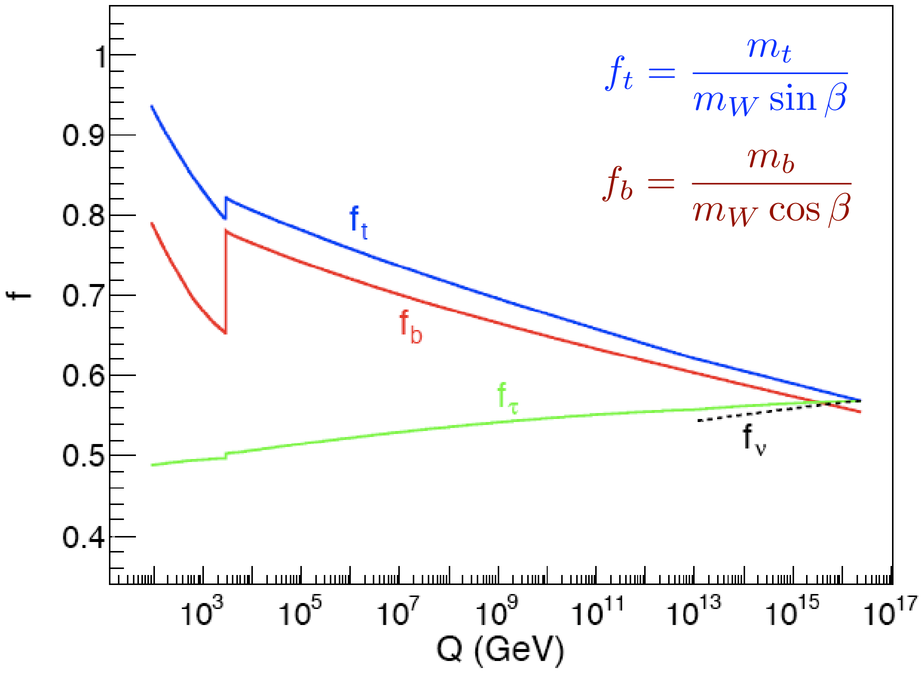
$$m_{H_{u,d}}^2 = m_{10}^2 \mp M_D^2$$

Conditions for Yukawa unification (YU)

★ YU can only be realized for very particular parameter relations (μ>0)

- $m_{16} \sim 5 - 15\ \mathrm{TeV},$
- $A_0^2 \simeq 2m_{10}^2 \simeq 4m_{16}^2, \quad (A_0 < 0)$
- $m_{1/2} \ll m_{16},$
- $\tan\beta \sim 50.$

$$R = \frac{max(f_t,\ f_b,\ f_\tau)}{min(f_t,\ f_b,\ f_\tau)}$$



★ D-term splitting

$$\begin{aligned} m_Q^2 = m_E^2 = m_U^2 &= m_{16}^2 + M_D^2 \\ m_D^2 = m_L^2 &= m_{16}^2 - 3M_D^2 \\ m_{\tilde\nu_R}^2 &= m_{16}^2 + 5M_D^2 \\ m_{H_{u,d}}^2 &= m_{10}^2 \mp 2M_D^2. \end{aligned}$$

$$\left(\frac{\delta m_b}{m_b}\right)^{\tilde g} \sim \frac{2\alpha_3}{3\pi}\,\mu\tan\beta\,\frac{m_{\tilde g}}{M_{SUSY}^2}$$

$$\left(\frac{\delta m_b}{m_b}\right)^{\tilde\chi^\pm} \sim \frac{f_t^2}{16\pi^2} A_t\ \tan\beta\ \frac{\mu}{M_{SUSY}^2}$$

NB: we need $m_{H_u}^2 < m_{H_d}^2$ at M_{GUT}, so $M_D^2 > 0$.

Important constraints from B physics

Conditions for Yukawa unification (YU)

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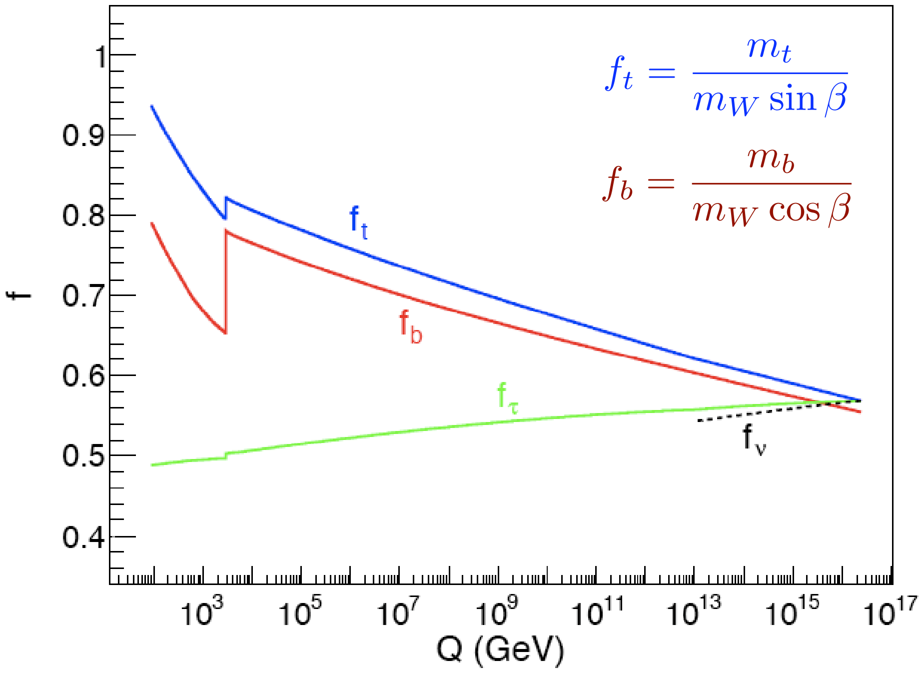
$$R = \frac{max(f_t,\ f_b,\ f_\tau)}{min(f_t,\ f_b,\ f_\tau)}$$



★ D-term splitting

$$\begin{aligned} m_Q^2 = m_E^2 = m_U^2 &= m_{16}^2 + M_D^2 \\ m_D^2 = m_L^2 &= m_{16}^2 - 3M_D^2 \\ m_{\tilde{\nu}_R}^2 &= m_{16}^2 + 5M_D^2 \\ m_{H_{u,d}}^2 &= m_{10}^2 \mp 2M_D^2. \end{aligned}$$

Higgs splitting (HS) case

NB: we need $m_{H_u}^2 < m_{H_d}^2$ at $M_{\rm GUT}$, so $M_D^2 > 0$.

$$\left(\frac{\delta m_b}{m_b}\right)^{\tilde{g}} \sim \frac{2\alpha_3}{3\pi}\,\mu\tan\beta\,\frac{m_{\tilde{g}}}{M_{SUSY}^2}$$

$$\left(\frac{\delta m_b}{m_b}\right)^{\tilde{\chi}^\pm} \sim \frac{f_t^2}{16\pi^2} A_t\,\tan\beta\,\frac{\mu}{M_{SUSY}^2}$$

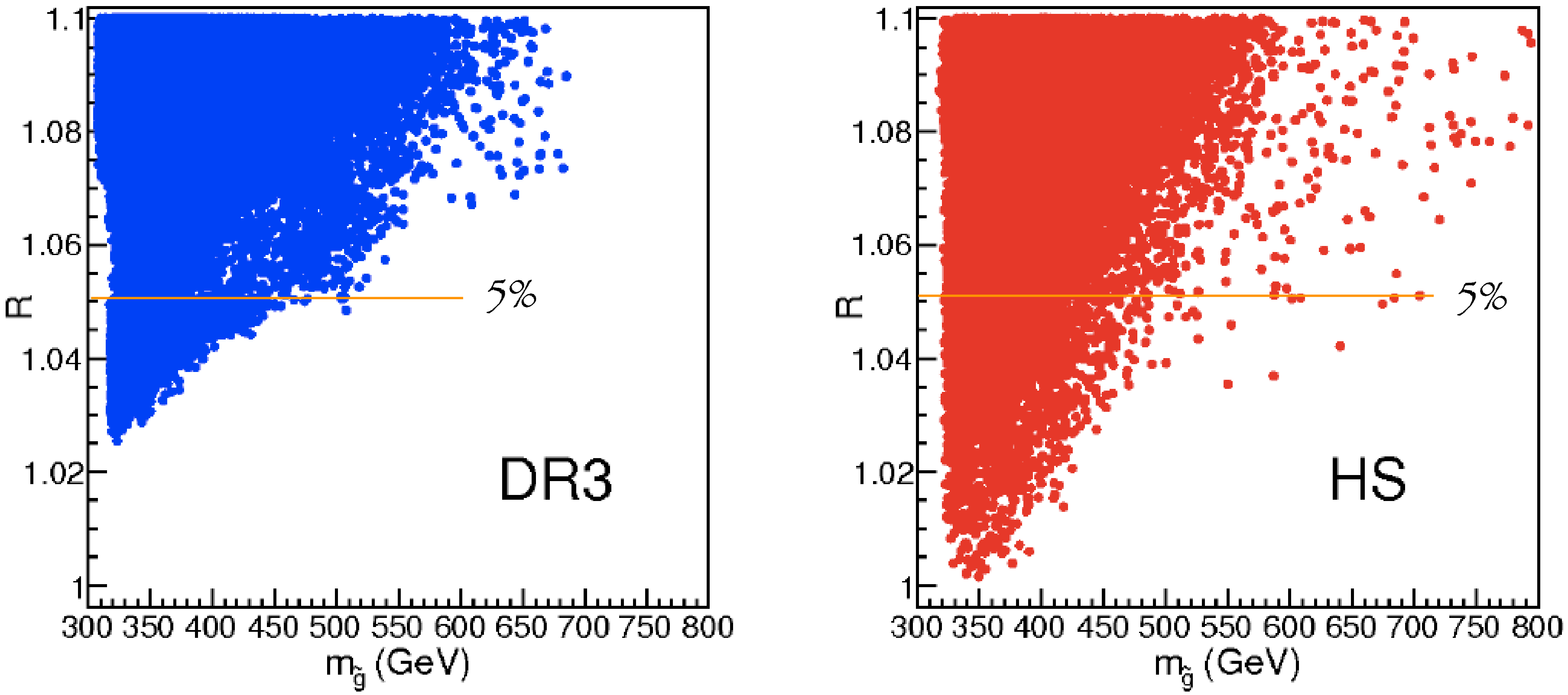
Important constraints from B physics

Baer et al, 0801.1831, 0809.0710, 0812.2693, 0908.0134, 0910.2988, 0911.4739.

Typical mass spectra

- 1st/2nd generation scalars in the multi-TeV range (5-15 TeV)
- 3rd gen. scalars, heavy Higgses and higgsinos in the 1-3 TeV range
- light gauginos: LSP ~ 50-80 GeV, gluino ~ 300-500 GeV
- c.f "effective SUSY" by Cohen, Kaplan, Nelson '1996

$$R = \frac{max(f_t,\ f_b,\ f_\tau)}{min(f_t,\ f_b,\ f_\tau)}$$

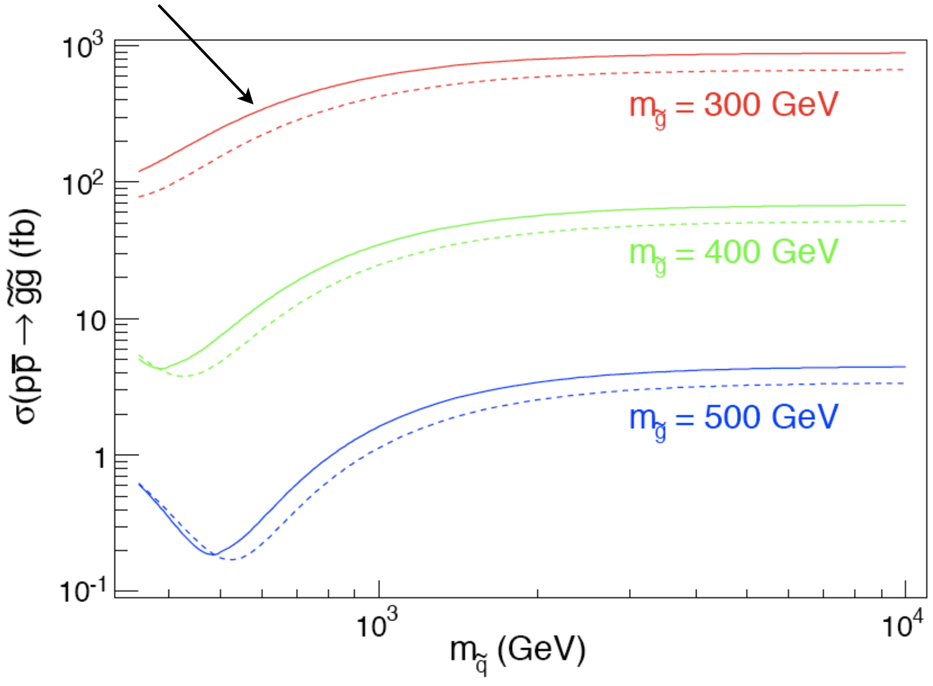


Points from a MCMC scan for small R

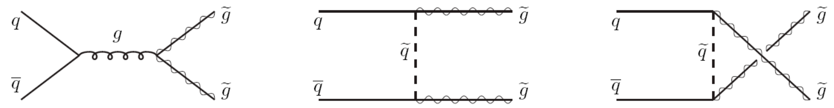
Baer et al, arXiv:0910.2988

Tevatron reach

current mSUGRA limit for heavy squarks (2fb^{-2})



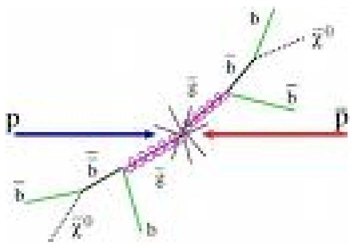
Gluino-pair prod. dominated by $q\bar q$ fusion. Negative interference of s-, t-, u-channels for m(squark)~m(gluino)!

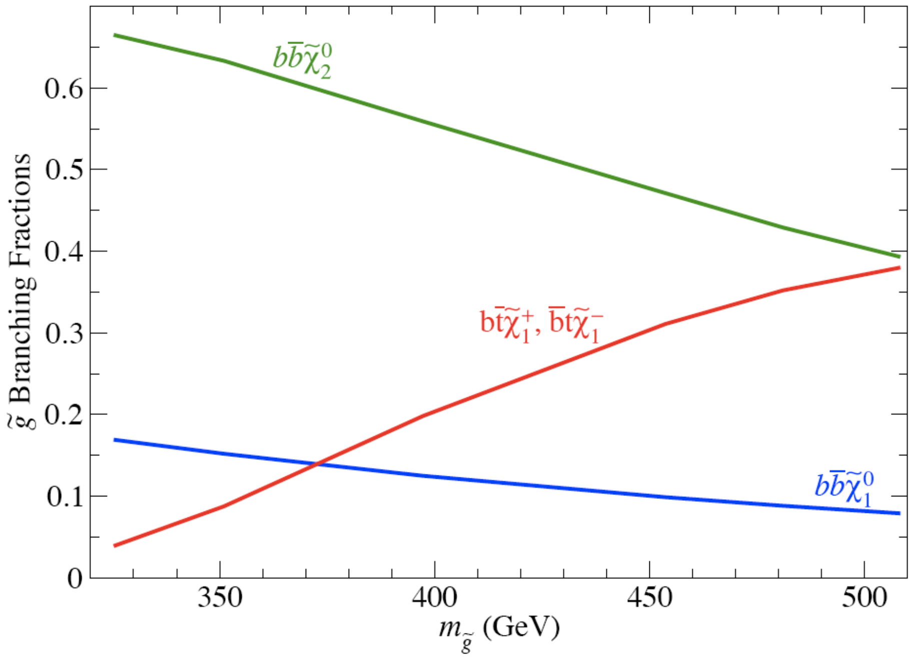


Xsection grows with increasing squark mass!

Gluino decays dominated by $\tilde\chi_2^0 b\bar b$ channel. We adopt a YU model line by starting from a HS point with m_{16}=10 TeV and R~1.02 and varying $m_{1/2}$.

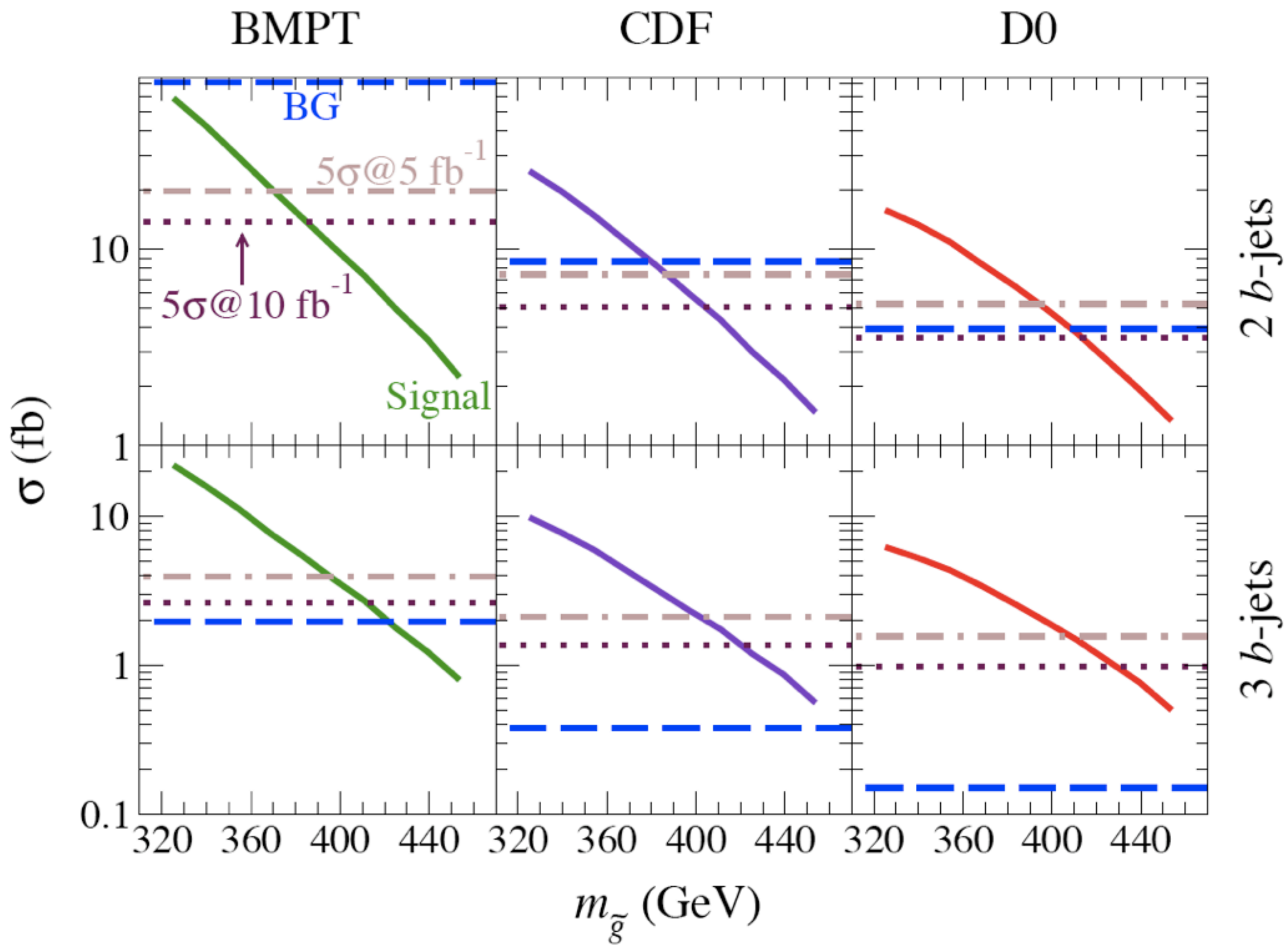
$$\begin{aligned} &m_{1/2} = 35 - 100 \text{ GeV},\\ &m_{\tilde g} = 325 - 508 \text{ GeV},\\ &R \to 1.07 \end{aligned}$$

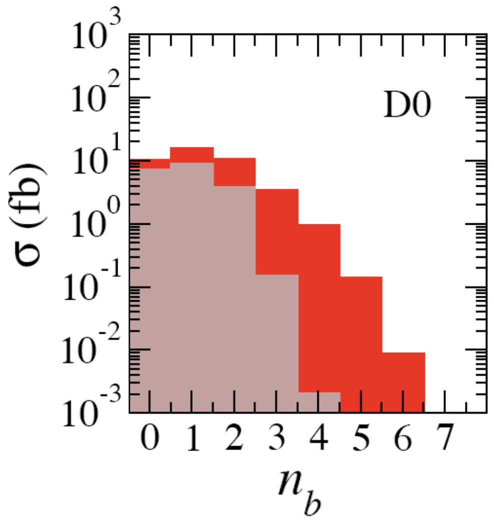




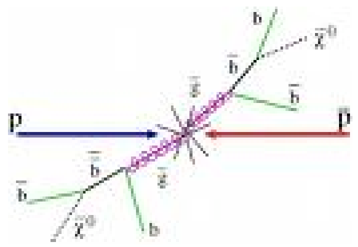
Baer et al, arXiv:0910.2988

Tevatron reach



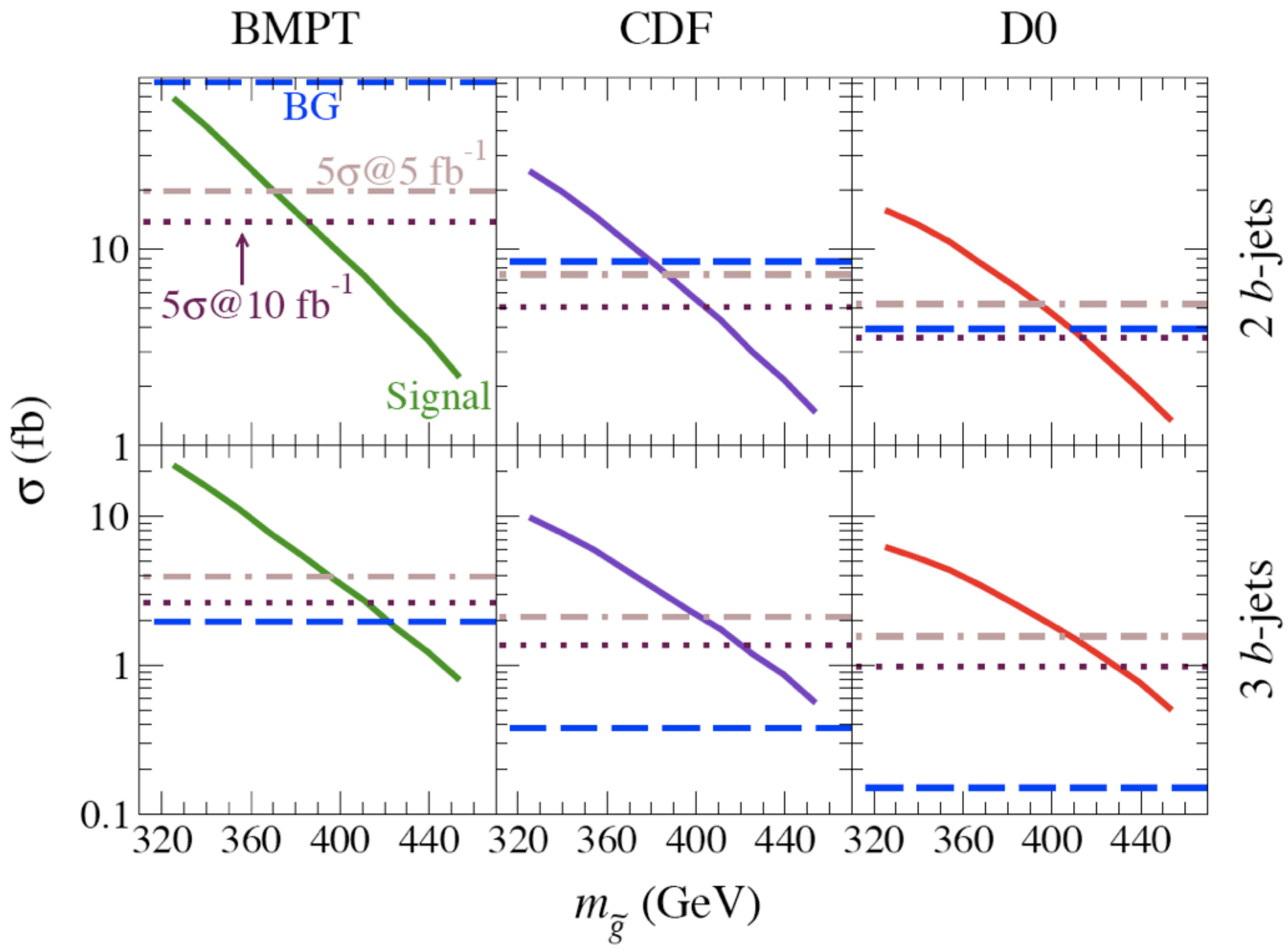


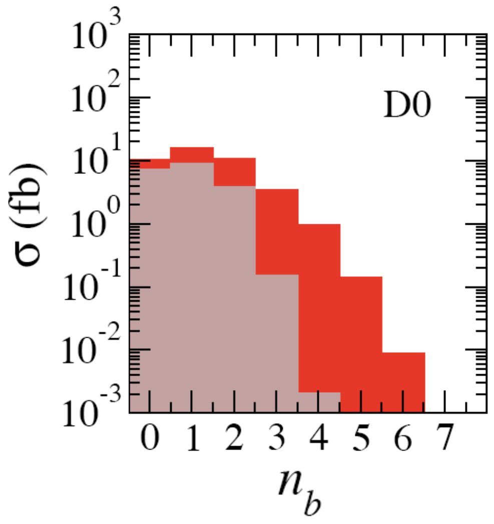
cuts	$E_T^{\rm miss}$	H_T	$E_T(j1)$	$E_T(j2)$	$E_T(j3)$	$E_T(j4)$
BMPT	≥ 75 GeV	–	15	15	15	15
CDF	≥ 90 GeV	280	95	55	55	25
D0	≥ 100 GeV	400	35	35	35	20



Baer et al, arXiv:0910.2988

Tevatron reach





With "D0" cuts and requiring ≥3 b-jets, 5σ discovery reach with 10 fb^{-1} about m(gluino)=430 GeV!

cuts	E_T^{miss}	H_T	$E_T(j1)$	$E_T(j2)$	$E_T(j3)$	$E_T(j4)$
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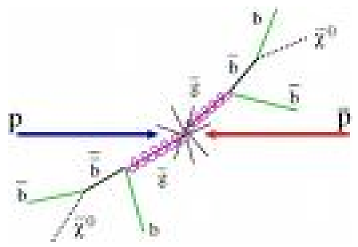
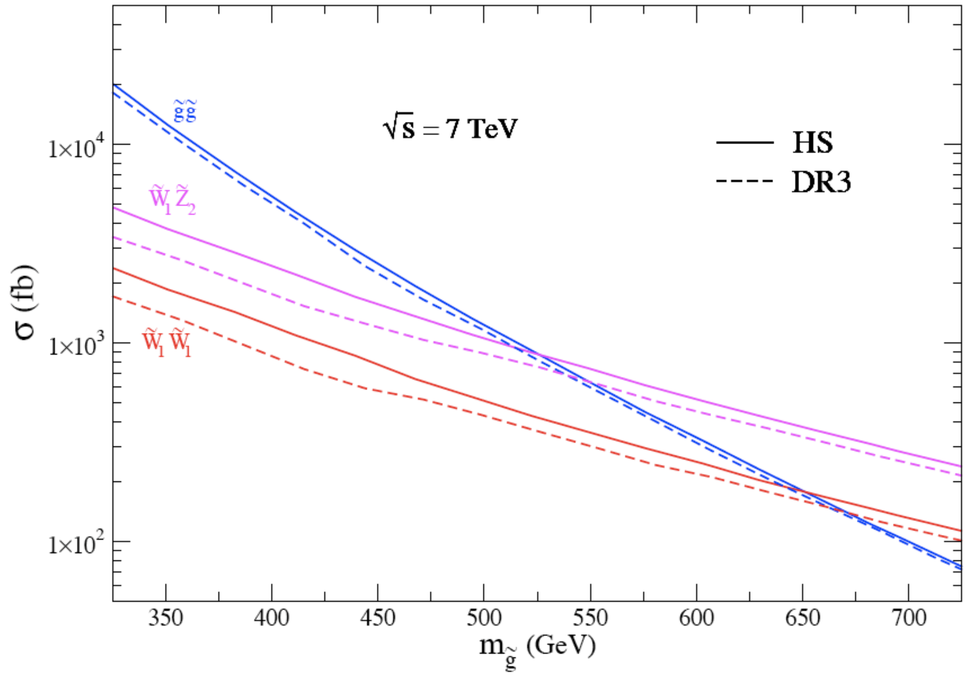


Baer et al, arXiv:0911.4739

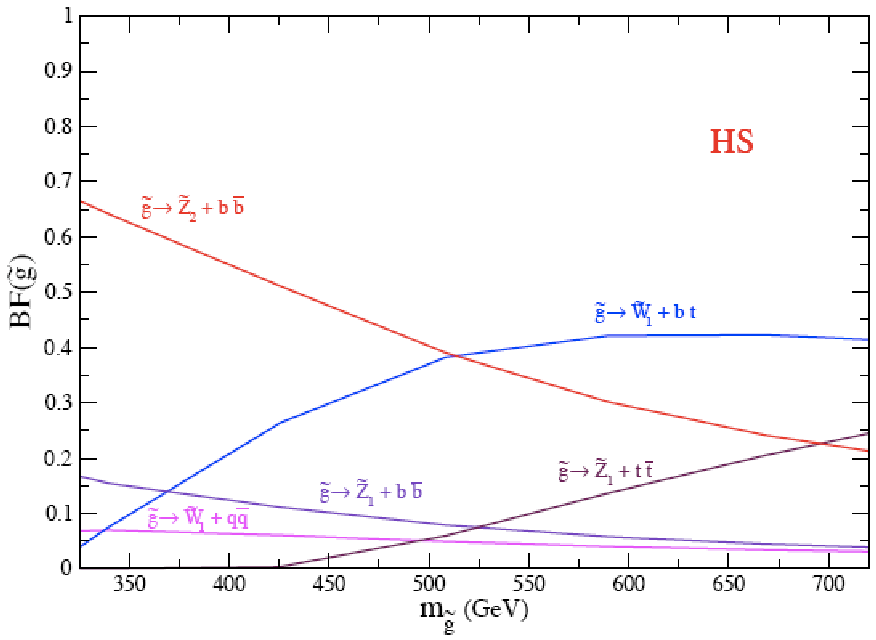
LHC reach at 7 TeV

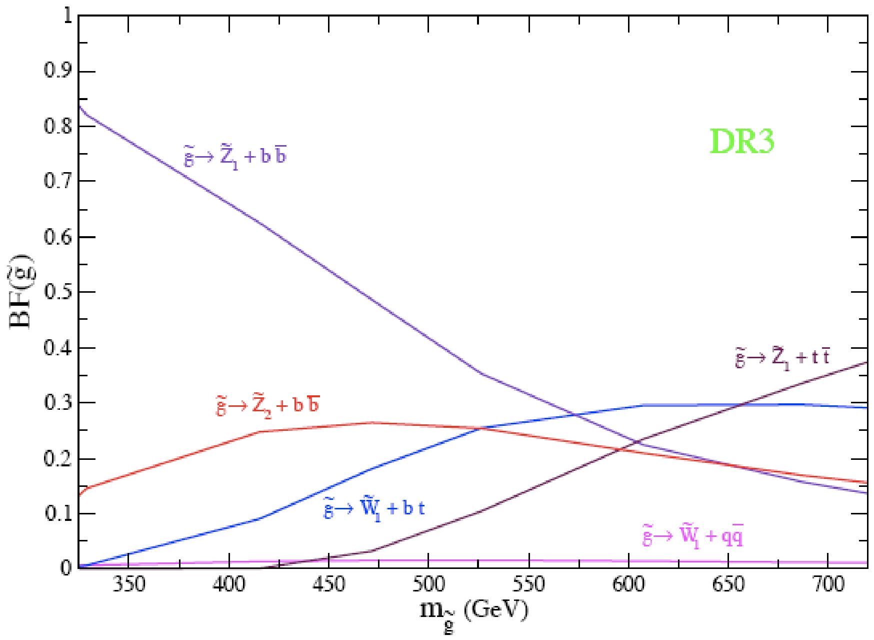


Gluino-pair prod. dominated by gg fusion. Much less enhancement from heavy squarks. σ(LO)~1 pb at m(gluino)~525 GeV

We consider model lines for HS and DR3 cases as function of m(gluino) up to 700 GeV.

Gluinos decays are again dominanted by heavy flavours: $\tilde{g} \to \tilde{\chi}^0_{1,2} b\bar{b},\ \tilde{\chi}^\pm_1 tb$



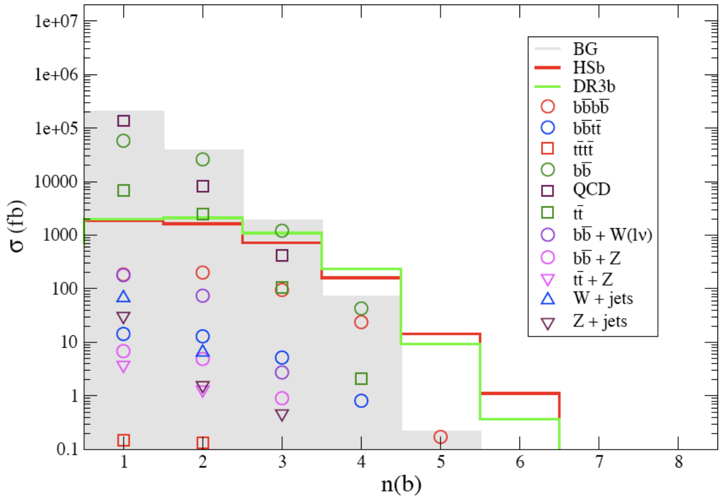


Baer et al, arXiv:0911.4739

LHC reach at 7 TeV

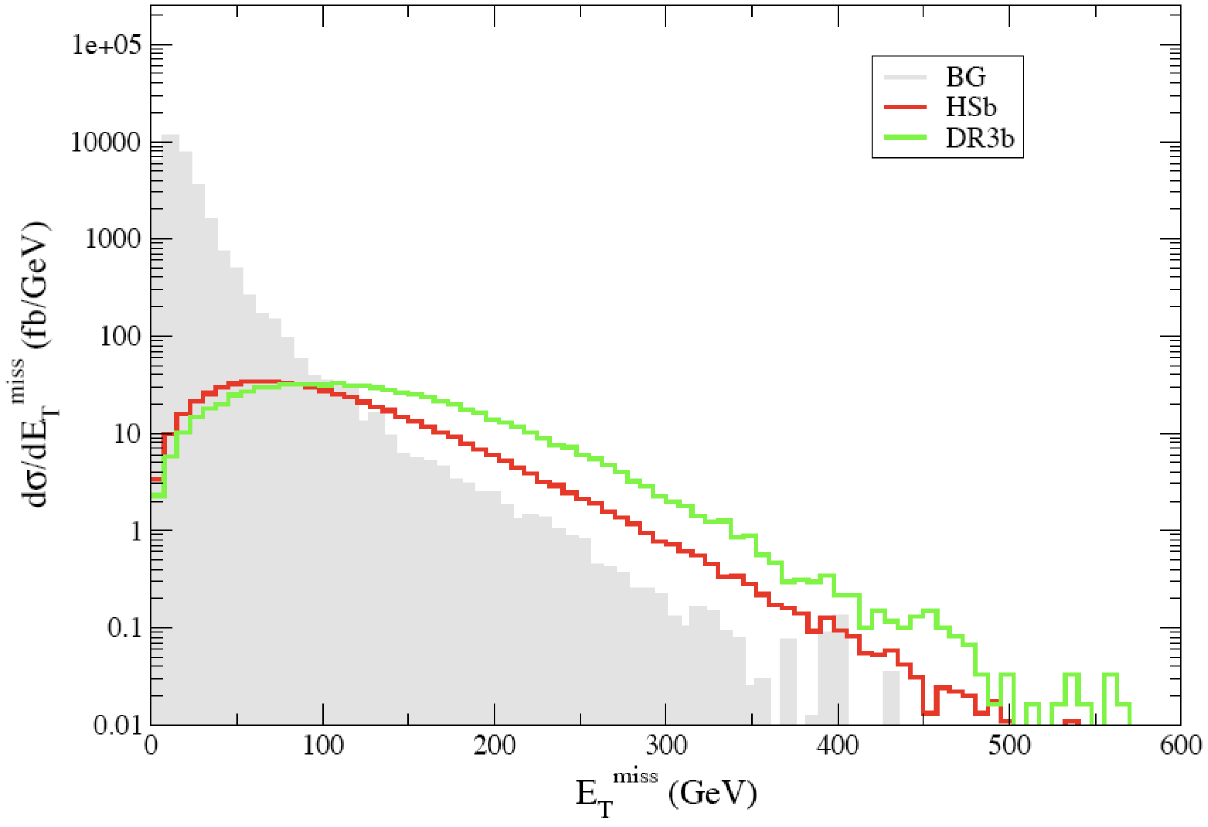
Event simulation:

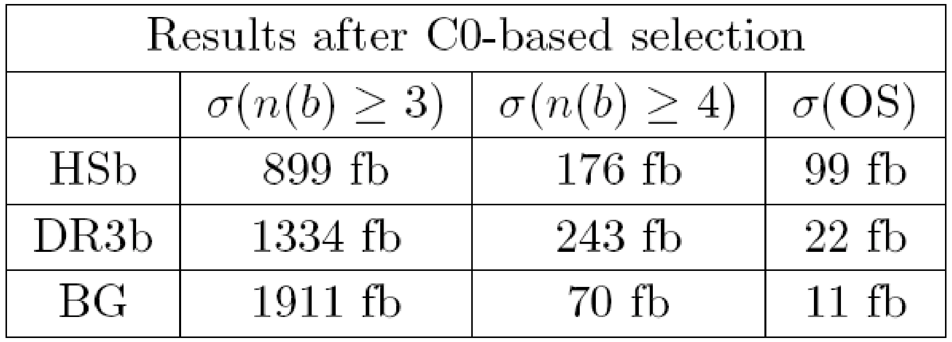
- Isajet 7.79 for the signal
- QCD, 2- and 3-bdy BGs with Alpgen
- 4t, 4b, 2t2b BGs with Madgraph
- Phythia for showering and hadronization
- Generic toy detector simulation



Basic Cuts "C0":

- n(jets)≥4 with $p_T > 50$GeV
- hardest jet $p_T > 100$ GeV
- $S_T \geq 0.2$ (transv sphericity)
- n(b) ≥ 1 (b-eff. 60%)





Results after C0-based selection

	$\sigma(n(b) \geq 3)$	$\sigma(n(b) \geq 4)$	$\sigma(\mathrm{OS})$
HSb	899 fb	176 fb	99 fb
DR3b	1334 fb	243 fb	22 fb
BG	1911 fb	70 fb	11 fb

Baer et al, arXiv:0911.4739

LHC reach at 7 TeV

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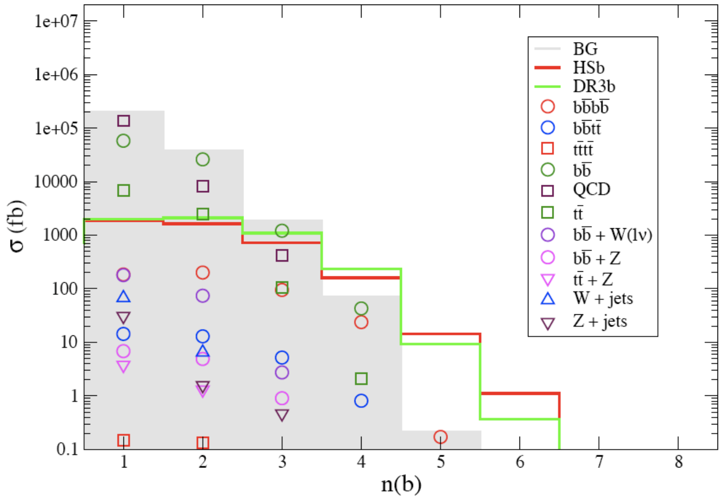

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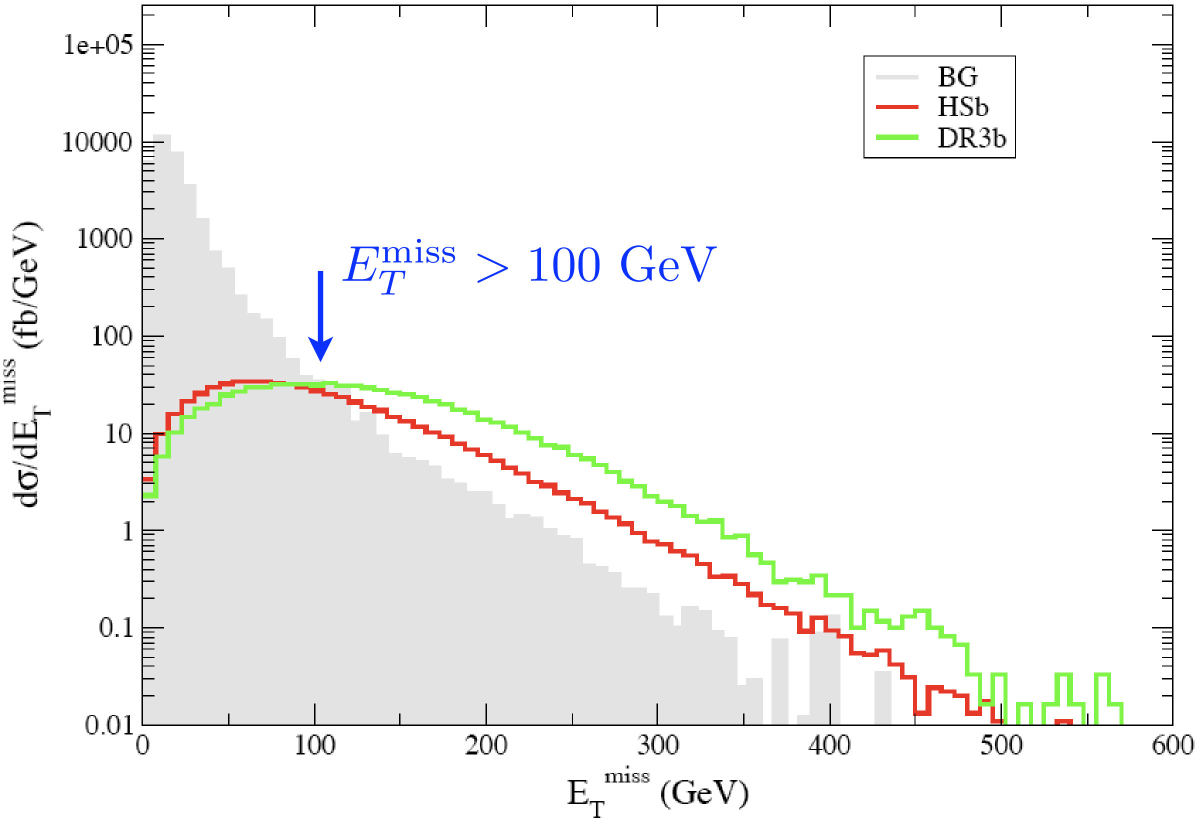

S. Kraml

Baer et al, arXiv:0911.4739

LHC reach at 7 TeV

Event simulation:

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- 4t, 4b, 2t2b BGs with Madgraph
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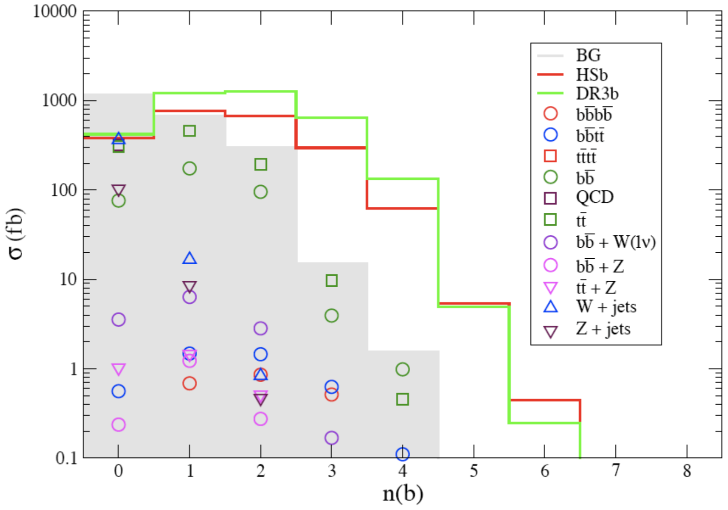
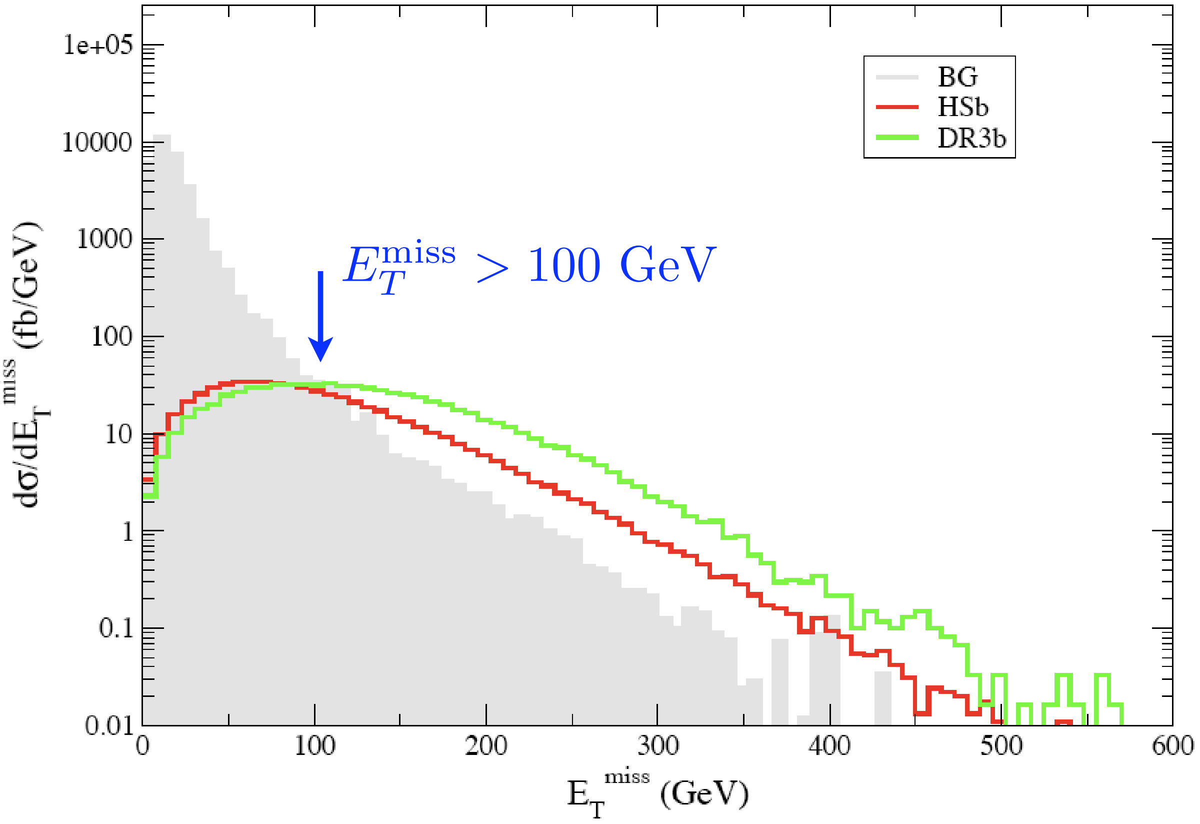
with cut on E_T^{miss}



Basic Cuts “C0”:

- n(jets)≥4 with p_T > 50GeV
- hardest jet p_T >100 GeV
- S_T ≥ 0.2 (transv sphericity)
- n(b) ≥ 1 (b-eff. 60%)

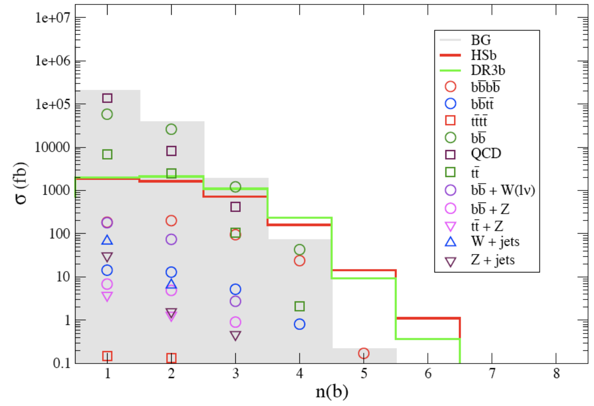
Results after C1-based selection			
	$\sigma(n(b) \geq 3)$	$\sigma(n(b) \geq 4)$	$\sigma(OS)$
HSb	364 fb	68 fb	81 fb
DR3b	782 fb	139 fb	23 fb
BG	16 fb	2 fb	9 fb

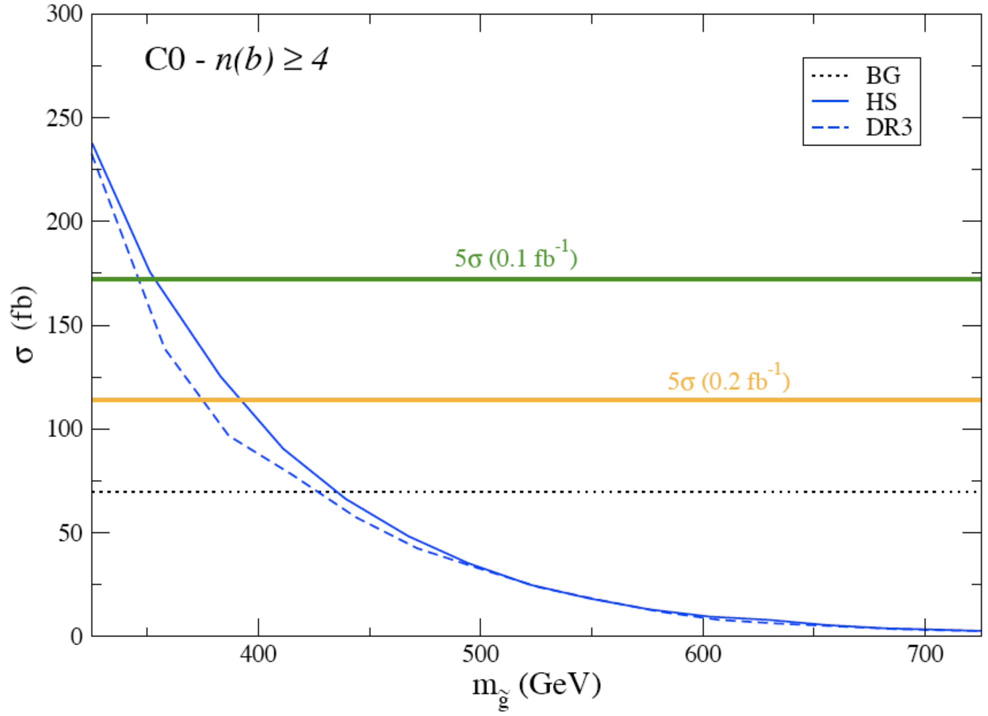


Baer et al, arXiv:0911.4739

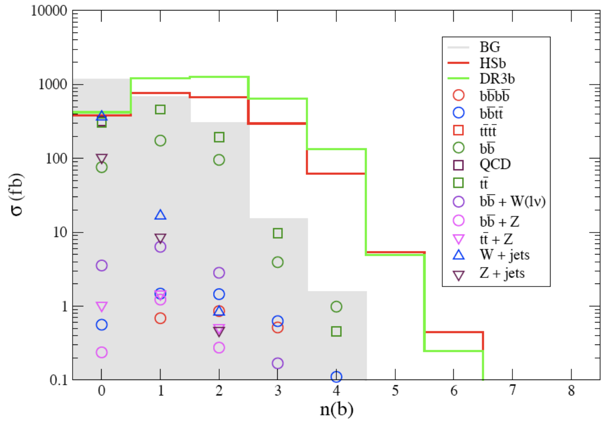
LHC reach at 7 TeV

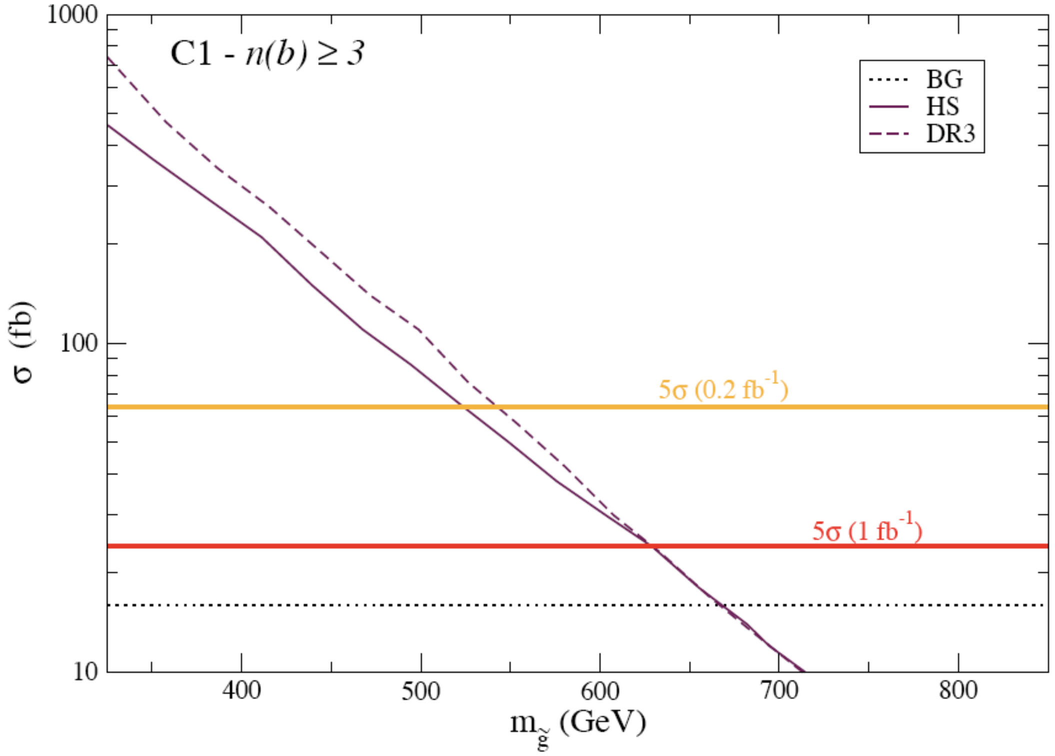
Without missing energy measurement:
up to m(gluino)=400 GeV with 0.2 fb^{-1} of data
requiring 4 b-jets





With reliable missing energy measurement:
reach up to m(gluino)=540-630 GeV
with 0.2-1 fb^{-1} of data,
n(b) ≥ 3





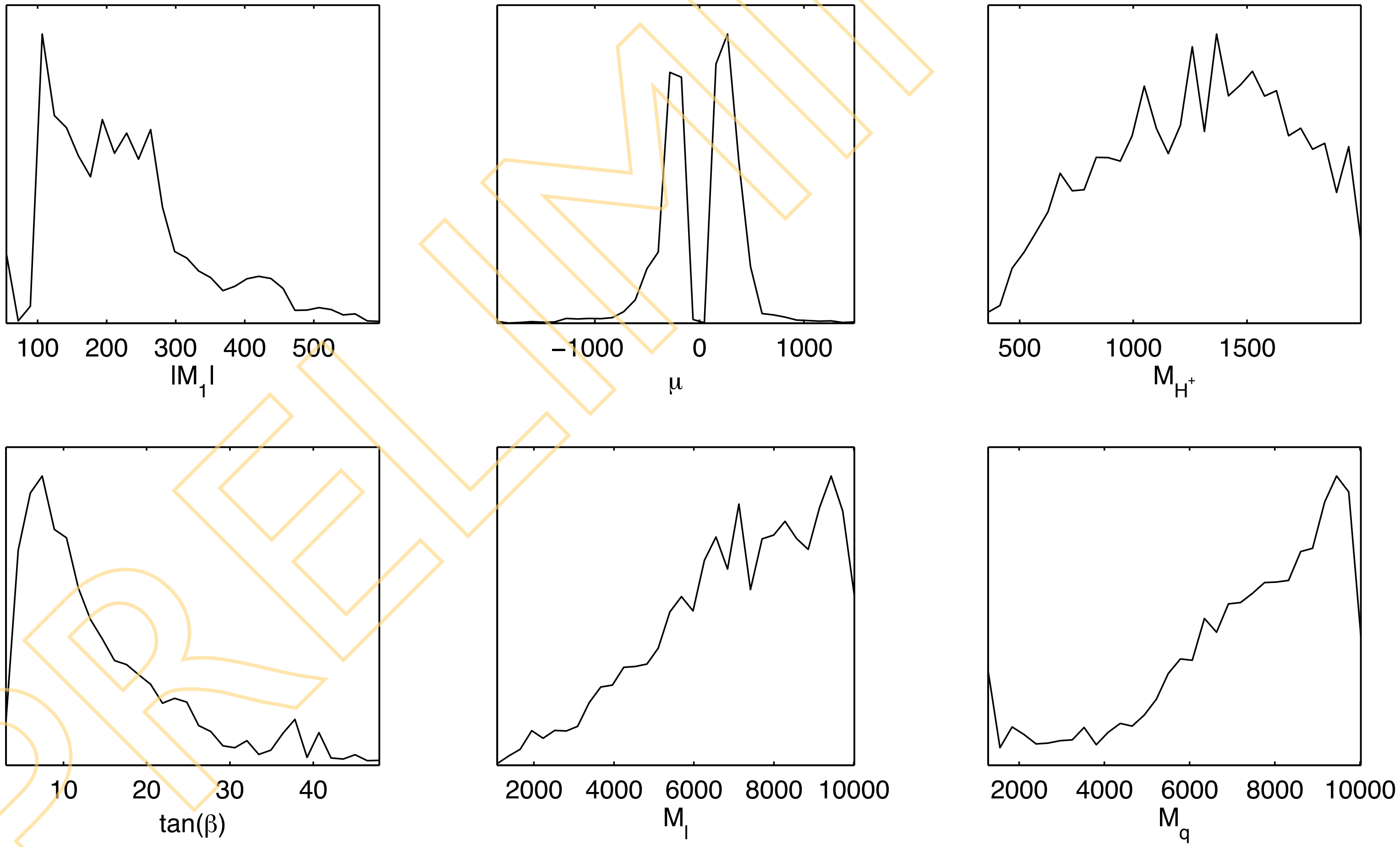
CP phases

$$\begin{aligned} \mu &= |\mu|\, e^{i\Phi_\mu} \\ M_i &= |M_i|\, e^{i\Phi_i} \\ A_f &= |A_f|\, e^{i\Phi_f} \end{aligned}$$

- Early 2009: limit on Hg EDM $2\times10^{-28} \rightarrow 3.1\times10^{-29}$ e cm

W. C. Griffith et. al., PRL 102 (2009) 101601

- MCMC analysis of the MSSM to explore remaining parameter space for SUSY CP violation: $(\Phi_\mu = 0,\ \pi)$



Belanger et al, in prog.

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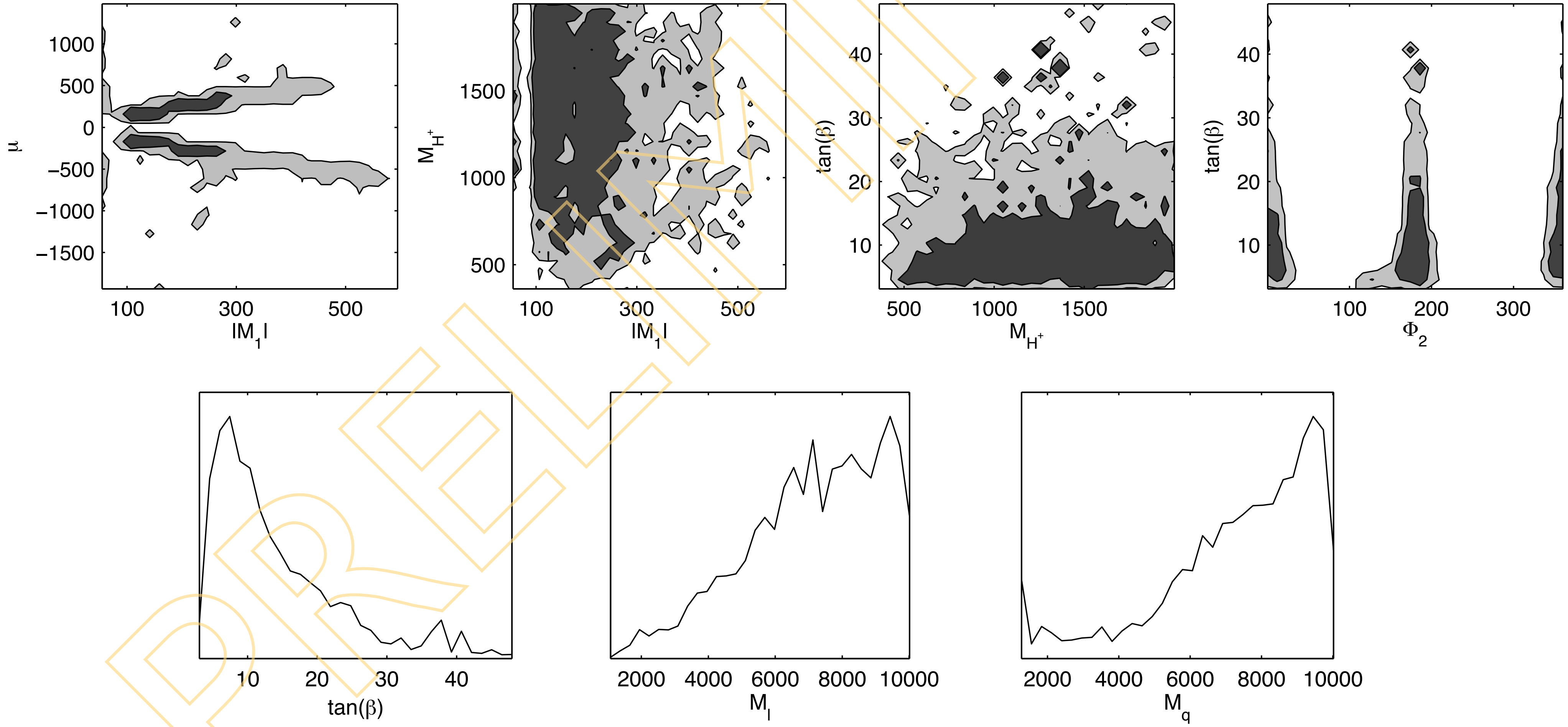

contours:
68% and
95% B.C.

Belanger et al, in prog.

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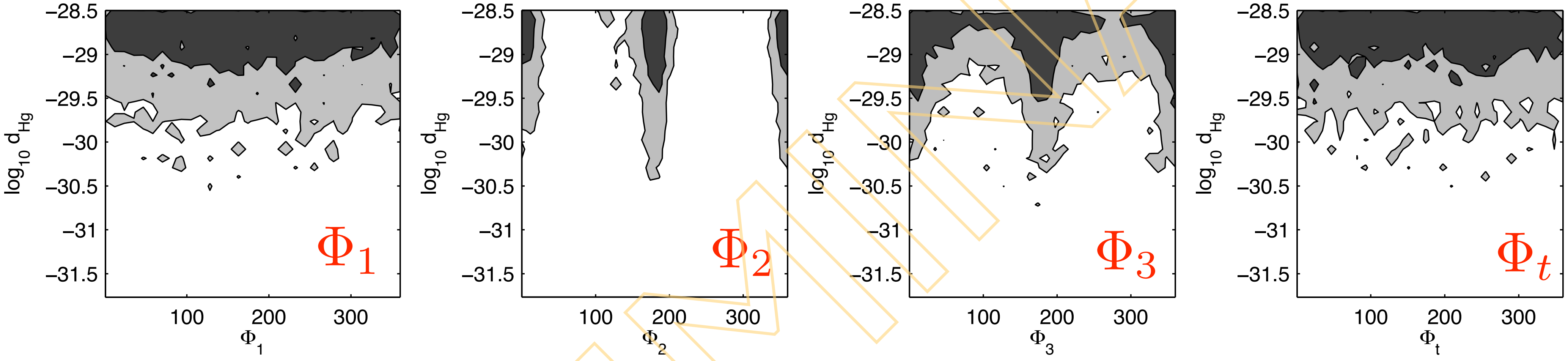
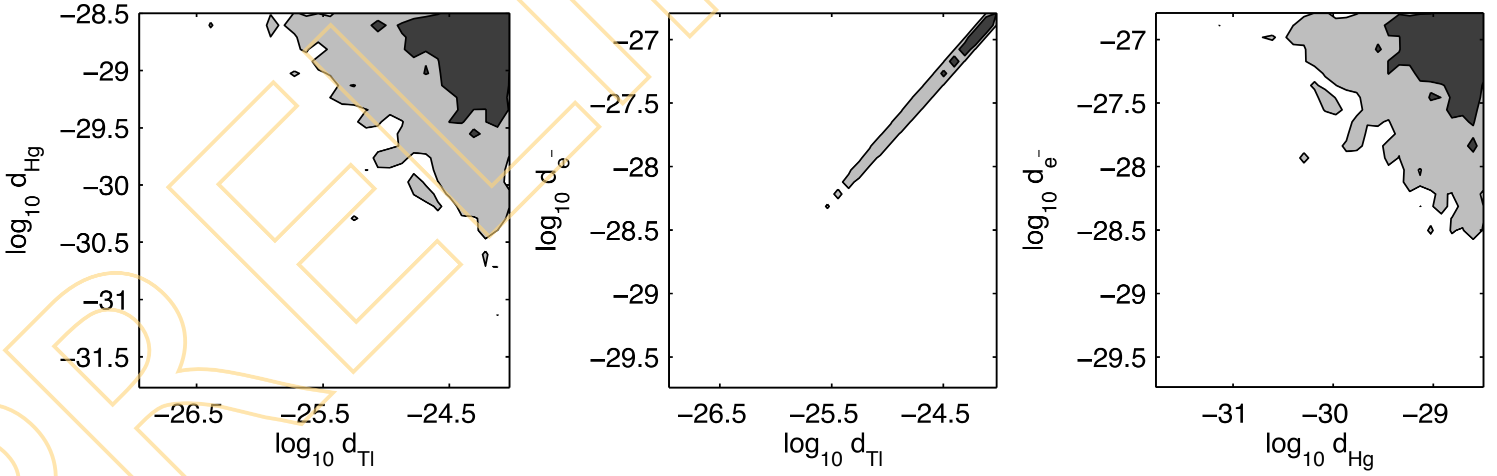


correlations of EDMs



$d(Hg) < 3.1\times10^{-29}$ (95%)
$d(Tl) < 9.0\times10^{-25}$ (90%)
$d(e^-) < 1.6\times10^{-27}$ (90%)

Belanger et al, in prog.

Conclusions

- MSSM and constrained versions thereof are in a good shape
  - large regions of parameter space compatible with exp. constraints
  - tension with LEP Higgs limit can be evaded
  - finetunig price may not be too high
- Important development of fitting tools
  (Sfitter, Fittino, SuperBayes, Mastercode, many private codes)
- Much of recent work has gone into Bayesian inference;
  fits show strong prior dependence → need more data
- Tevatron/LHC have good potential for "effective SUSY"
  (light gauginos [gluino], TeV-scale 3rd generation, multi-TeV 1st/2nd gen)
- Example: Yukawa-unified SUSY SO(10)
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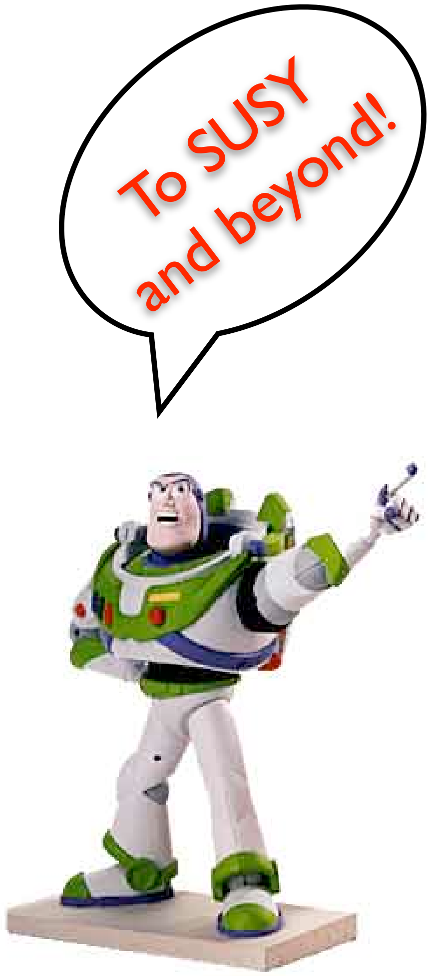
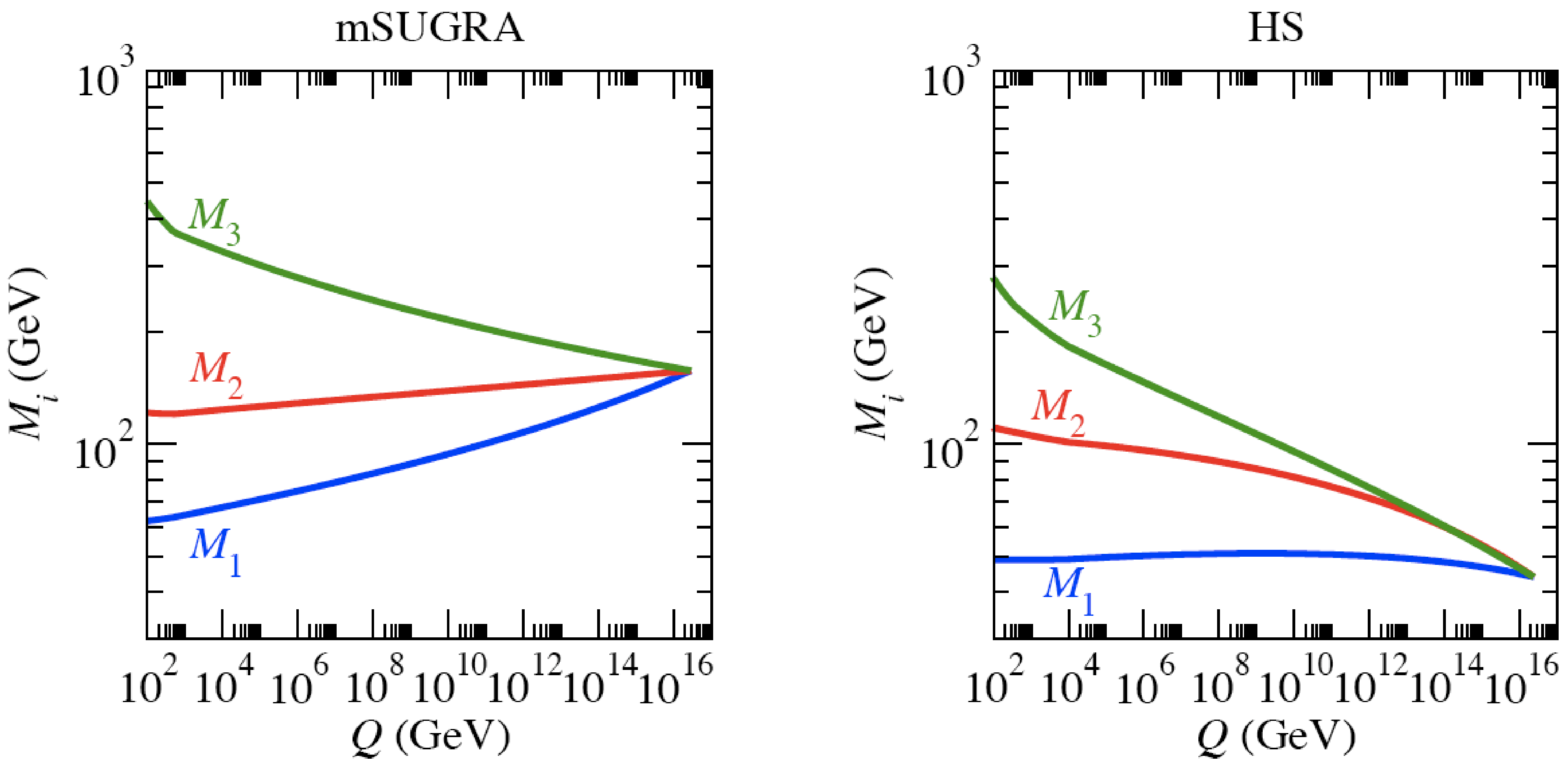
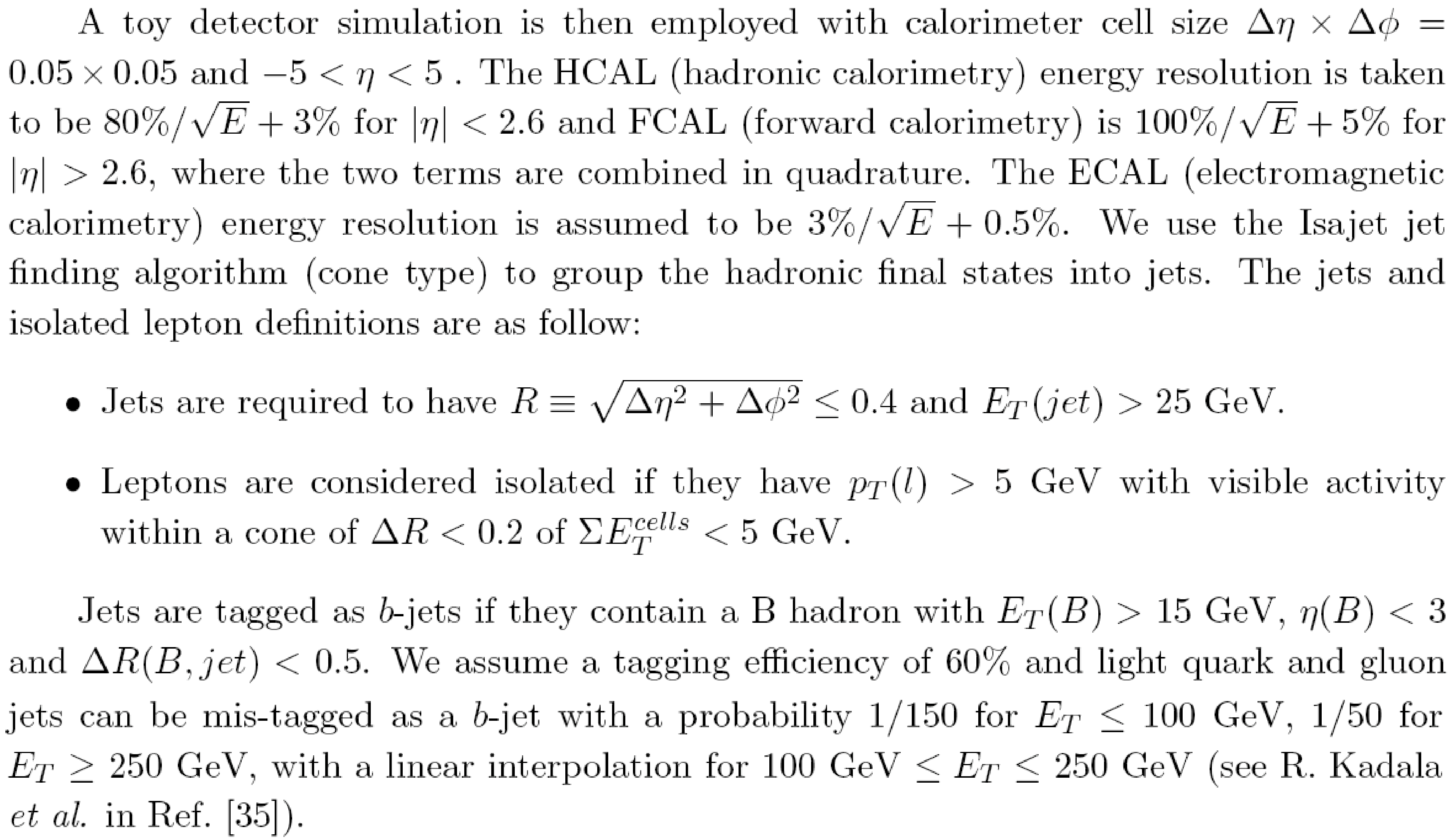


Backup



Evolution of gaugino masses in mSUGRA and Yukawa-unified SO(10) HS model

- Event simulation for LHC @ 7 TeV

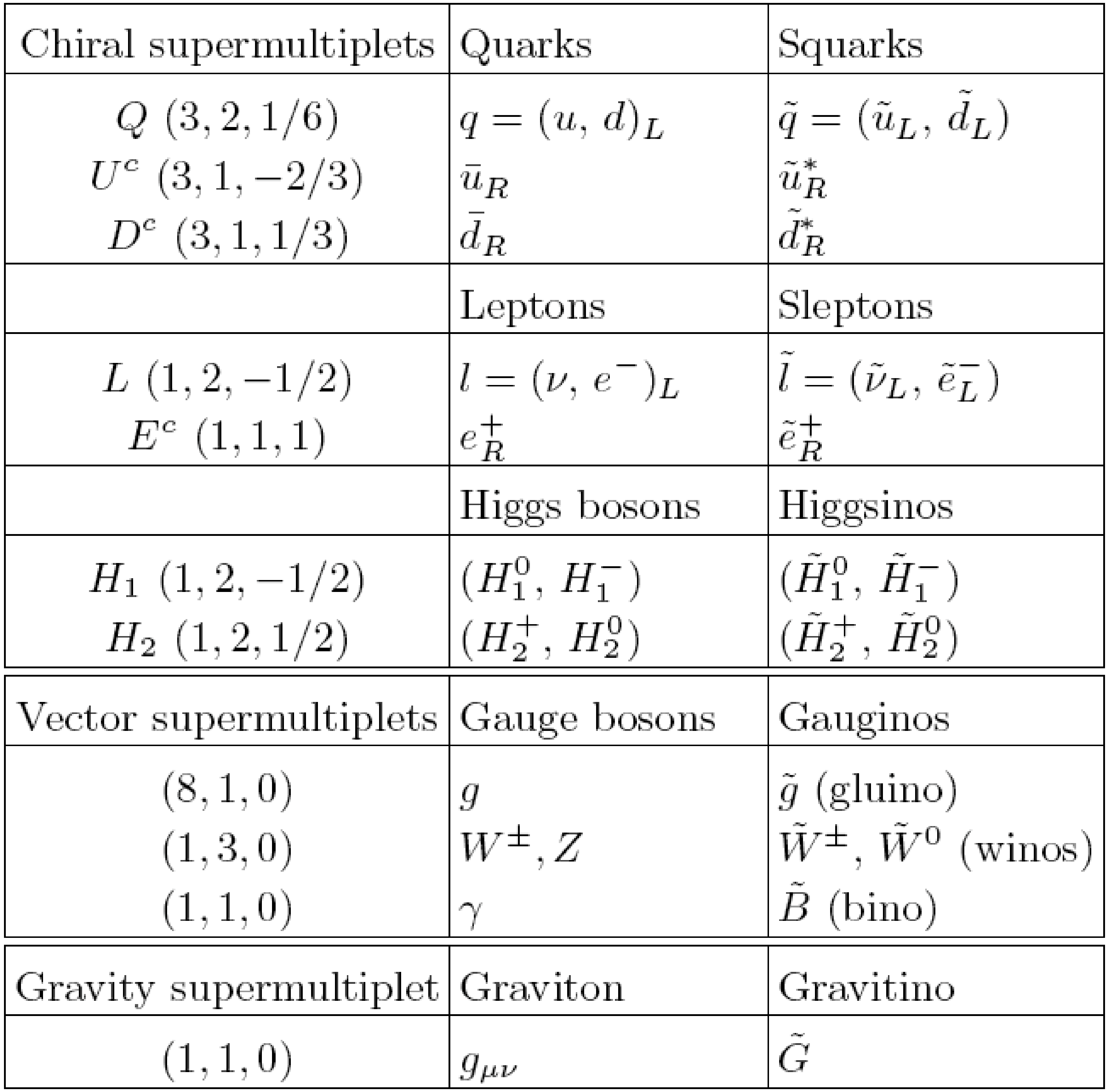


A toy detector simulation is then employed with calorimeter cell size $\Delta\eta \times \Delta\phi = 0.05 \times 0.05$ and $-5 < \eta < 5$. The HCAL (hadronic calorimetry) energy resolution is taken to be $80\%/\sqrt{E} + 3\%$ for $|\eta| < 2.6$ and FCAL (forward calorimetry) is $100\%/\sqrt{E} + 5\%$ for $|\eta| > 2.6$, where the two terms are combined in quadrature. The ECAL (electromagnetic calorimetry) energy resolution is assumed to be $3\%/\sqrt{E} + 0.5\%$. We use the Isajet jet finding algorithm (cone type) to group the hadronic final states into jets. The jets and isolated lepton definitions are as follow:

- Jets are required to have $R \equiv \sqrt{\Delta\eta^2 + \Delta\phi^2} \leq 0.4$ and $E_T(jet) > 25$ GeV.
- Leptons are considered isolated if they have $p_T(l) > 5$ GeV with visible activity within a cone of $\Delta R < 0.2$ of $\Sigma E_T^{cells} < 5$ GeV.

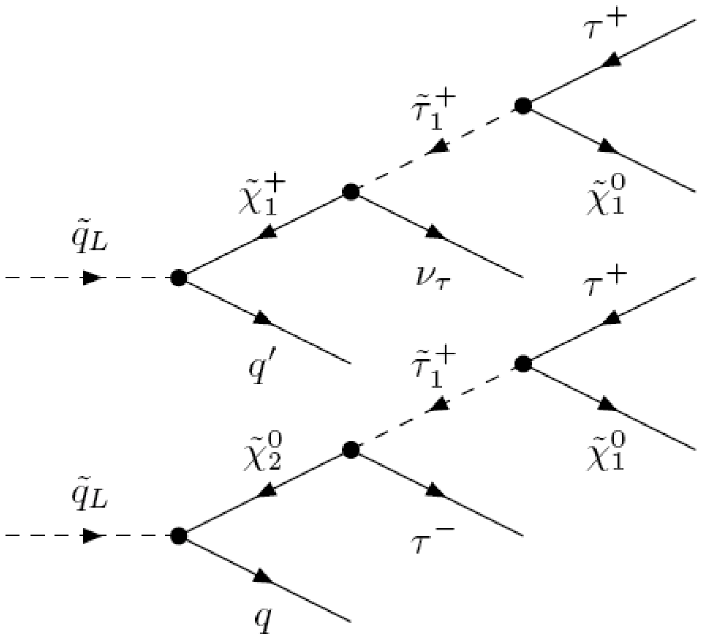
Jets are tagged as b-jets if they contain a B hadron with $E_T(B) > 15$ GeV, $\eta(B) < 3$ and $\Delta R(B, jet) < 0.5$. We assume a tagging efficiency of 60% and light quark and gluon jets can be mis-tagged as a b-jet with a probability 1/150 for $E_T \leq 100$ GeV, 1/50 for $E_T \geq 250$ GeV, with a linear interpolation for 100 GeV $\leq E_T \leq$ 250 GeV (see R. Kadala *et al.* in Ref. [35]).

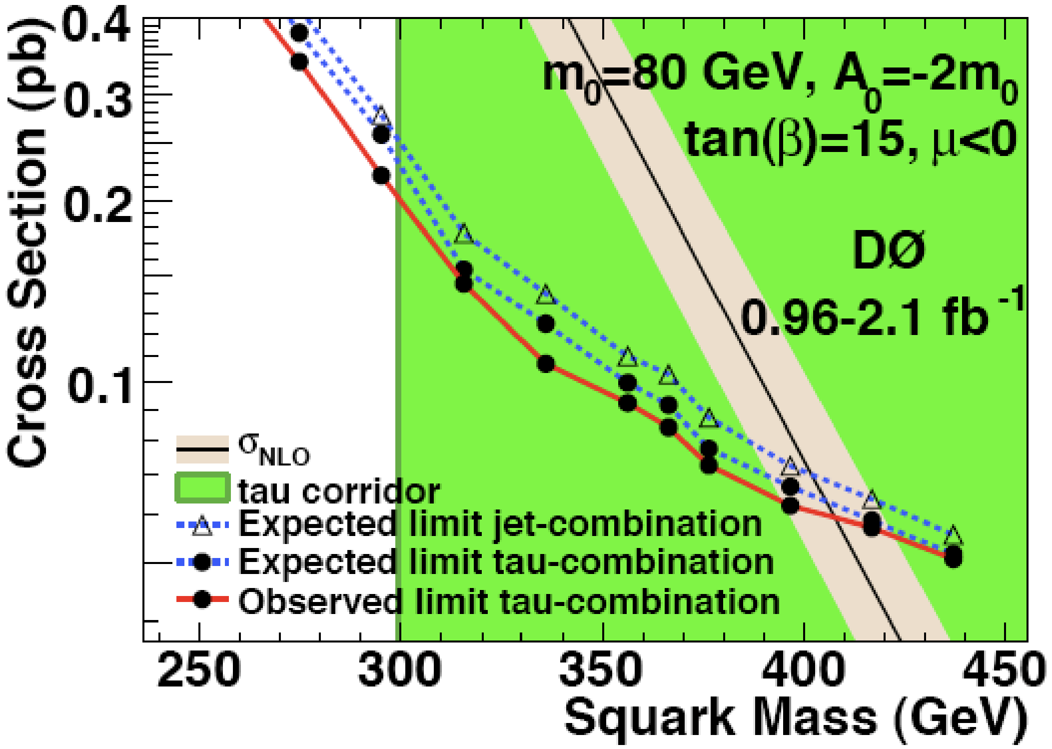
MSSM particle content

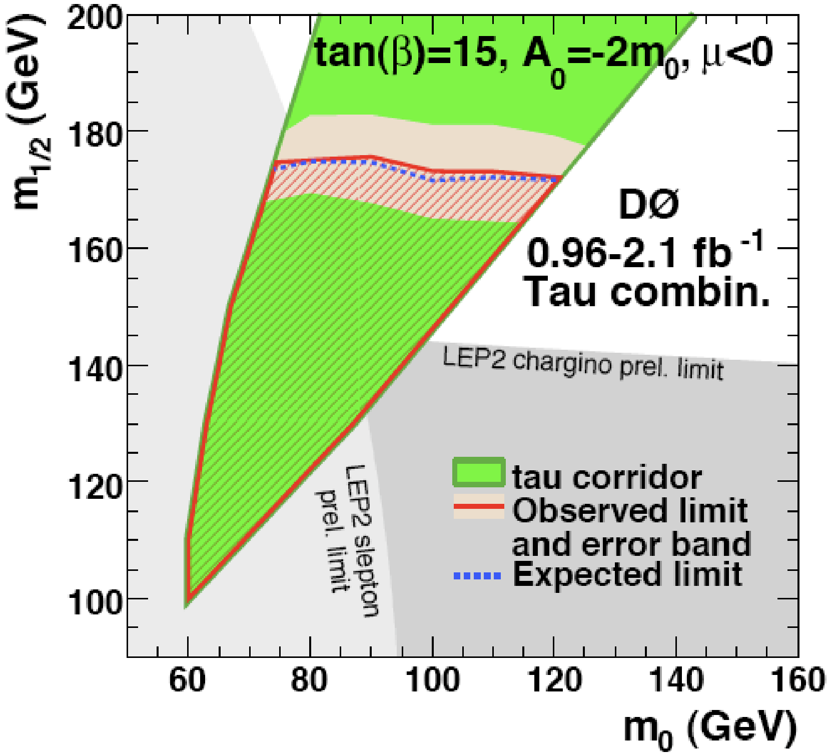


Chiral supermultiplets	Quarks	Squarks
$Q\ (3,2,1/6)$	$q = (u,\, d)_L$	$\tilde q = (\tilde u_L,\, \tilde d_L)$
$U^c\ (3,1,-2/3)$	$\bar u_R$	$\tilde u_R^*$
$D^c\ (3,1,1/3)$	$\bar d_R$	$\tilde d_R^*$
	Leptons	Sleptons
$L\ (1,2,-1/2)$	$l = (\nu,\, e^-)_L$	$\tilde l = (\tilde\nu_L,\, \tilde e_L^-)$
$E^c\ (1,1,1)$	e_R^+	$\tilde e_R^+$
	Higgs bosons	Higgsinos
$H_1\ (1,2,-1/2)$	$(H_1^0,\, H_1^-)$	$(\tilde H_1^0,\, \tilde H_1^-)$
$H_2\ (1,2,1/2)$	$(H_2^+,\, H_2^0)$	$(\tilde H_2^+,\, \tilde H_2^0)$
Vector supermultiplets	Gauge bosons	Gauginos
$(8,1,0)$	g	$\tilde g$ (gluino)
$(1,3,0)$	$W^\pm, Z$	$\tilde W^\pm,\, \tilde W^0$ (winos)
$(1,1,0)$	γ	$\tilde B$ (bino)
Gravity supermultiplet	Graviton	Gravitino
$(1,1,0)$	$g_{\mu\nu}$	$\tilde G$

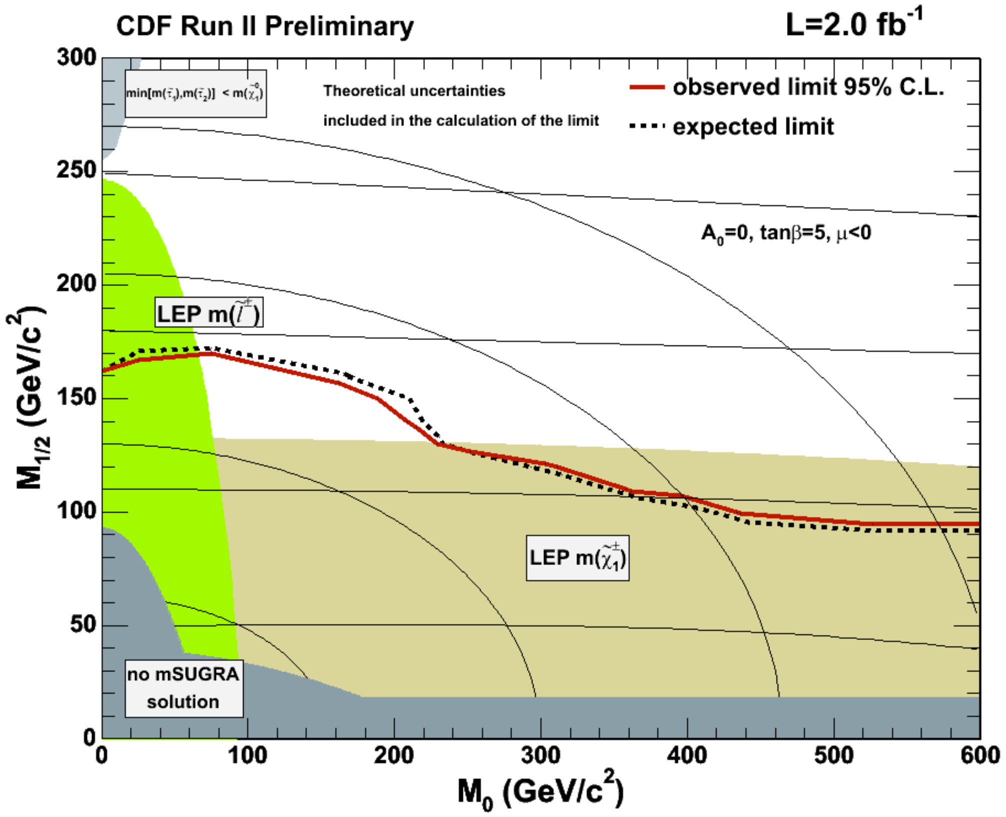
D0 search for squarks / tau channel

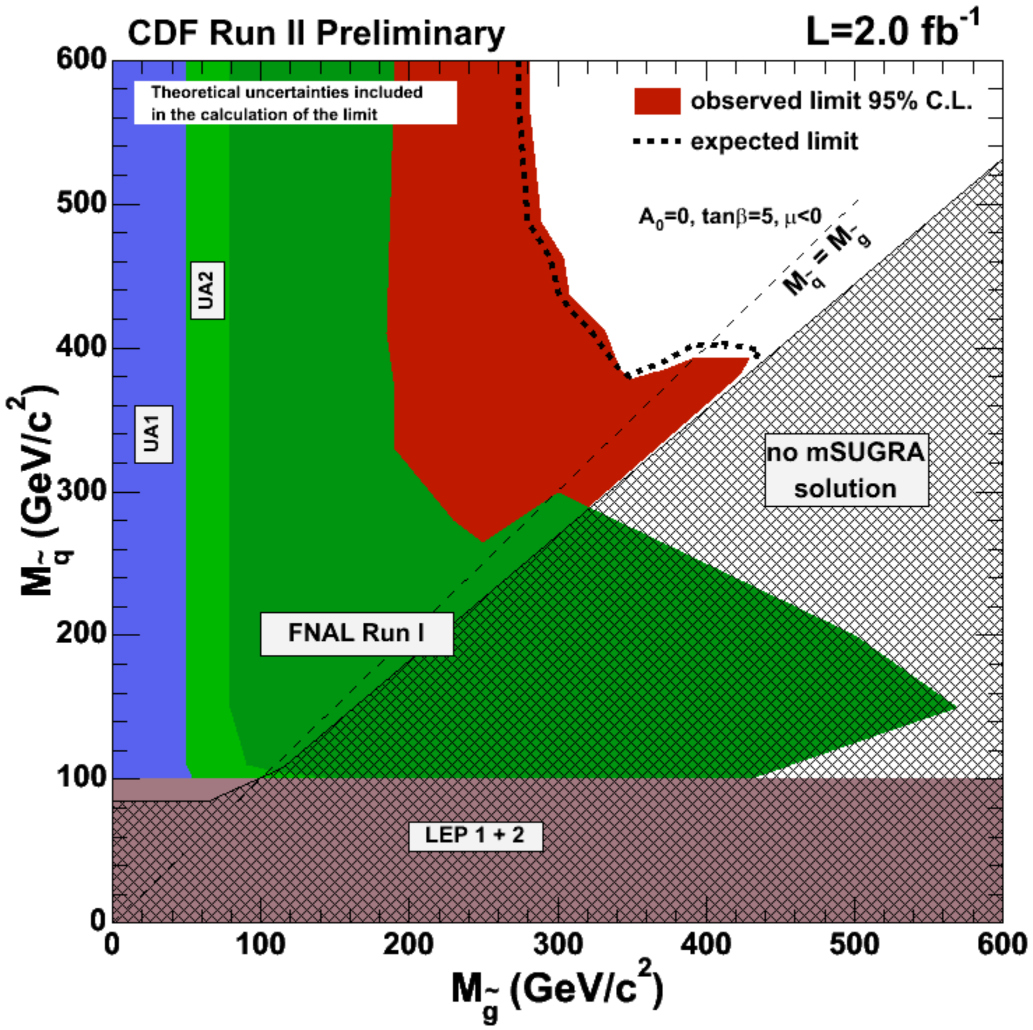






CDF search for gluinos/squarks





Yukawa-unified SUSY @ 7TeV LHC